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ON THE DEVELOPMENT OF CERTAIN PIPERACEAE.

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(WITH PLATES IX–X)

IN an earlier paper on Peperomia I stated (Johnson, 1900[a], p. 9) that Piper and Heckeria have "essentially typical Angiosperm embryo-sacs." This statement was based on observations covering the critical stages in the development of this structure. Since then I have studied the embryo-sac in these genera in detail, for the purpose of discovering any possible clue to the derivation of the peculiar type of embryo-sac found in the related genus Peperomia. The more important results of a study of these forms are given here, together with an account of the fate during germination of the various structures found in the fruit of Peperomia.

I. THE OVULE, SEED, AND FRUIT OF PIPER.

The two species of Piper studied were *Piper adunca* L. and a species determined as *Piper medium* Jacq. The development of the former, as far as followed, agreed closely with that of *Piper medium;* it will therefore suffice to describe and figure the latter in detail.

The flowers of *Piper medium* occur rather loosely scattered on a spike 4 to 8[cm] in length. In the development of the flower the three outer stamens appear first, then the three inner ones. Each stamen has four pollen-sacs (*fig. 1, ps*), and the whole development of the stamens shows no noteworthy peculiarities. Soon after the stamens are formed the wall of the ovary appears

as a usually three-lobed ring just within the inner row of stamens (*fig. 2, cp*). These lobes ultimately fuse together except the stigmatic tips (*fig. 1, st*), and form a rather fleshy ovary wall, with at first a broad, somewhat capitate tip (*figs. 5, 11*). Finally the ovary becomes somewhat barrel-shaped, and when ripe is about 2^{mm} long and 1.5^{mm} in diameter, while the withered stigmas appear as slight papillae at the upper end (*fig. 14, st*).

From an early stage of development there are found in the wall of the ovary numerous scattered oil-secreting cells with nucleated protoplasts (*figs. 5, 11, oc*). In the nearly ripe fruit the carpellary tissue is differentiated into three distinct layers, the outer including the epidermis. The latter is made up of slightly elongated cells with papillose outer walls. At the base of the ovary are found a few scattered, multicellular, pointed hairs similar to those found more abundantly on the base of the spike, and to those shown for Heckeria in *fig. 16*. The first layer of tissue below the epidermis is of several layers of rather loose parenchyma cells, among which are scattered oil-containing cells (*figs. 11, 14, 15, cp^1*). The second tissue layer is of from five to ten layers of closely packed cells, elongated longitudinally to the fruit and without interspersed oil-cells (*figs. 11, 14, 15, cp^2*). While both these outer layers of the ovary wall are continuous around the whole circumference, the third and innermost layer is discontinuous and confined to the six longitudinal grooves in the integument (*figs. 14, 15, cp^3*). This layer is made up of somewhat elongated cells with trabeculate walls, thickly interspersed with oil-cells. At the border between the second and third layers and opposite the grooves in the integument occur strands of vascular tissue (*figs. 11, 14, 15, vb*), showing from three to eight or ten tracheids in transverse section. These strands continue on into the loose parenchyma of the stylar region where the tracheids become considerably swollen and sometimes detached from each other (*figs. 11, 14*).

The ovule, which is terminal on the axis, arises just as the carpel lobes are closing in above. The two integuments appear nearly simultaneously just after the archesporial cell becomes distinguishable (*fig. 3, iin, oin*). The outer integument soon

becomes much longer than the inner and closes together above the latter (*figs. 5, 6*). The inner integument a little later becomes much thicker than the outer, of three layers except near the micropylar end, and finally forms the principal seed-coat (*figs. 6, 11, 12, 13, 15, iin*). One or two layers of cells of the outer integument are recognizable in the ripe seed. The inner walls of the inner layer are thickened with a granular deposit resembling that found in the inner layer of carpellary cells in Peperomia. The primary hypodermal archesporial cell divides before the integuments have developed far, to form a tapetal cell above and the definitive archesporial cell below (*fig. 4, tp, es*). The tapetal cell later divides further to form four or five layers of cells above the embryo sac in the ripe seed (*figs. 8, 12, 13, tp*), not however, forming so sharply marked a group of cells as in *Peperomia pellucida* (Johnson, 1900[a], p. 2). The single definitive archesporial cell becomes a megaspore directly, without further division. It increases greatly in size, as does its nucleus also (*fig. 6, es*), but in so doing does not encroach upon the cells above it in the nucellus in such a way as to indicate that these are anything other than tapetal cells (*figs. 6, 7, 8, 9, es, tp*). No evidence was discovered at any stage of the formation of sister megaspores destined to final absorption by the functional one, as in so many Angiosperms.

The division of the megaspore occurs soon after the inner integument has closed in to form a narrow micropyle above the nucellus. This division occurs in the manner so frequently described. Of the first two nuclei formed one goes to each pole and there each divides (*fig. 7*). The four nuclei thus formed are frequently found grouped rather closely in the middle of the embryo sac (*fig. 8*), or in other cases we find a pair near each pole. The eight nuclei formed at the next division soon group themselves in the typical manner to form the ripe embryo sac (*fig. 9*). The exact derivation of the polar nuclei has not been made out with absolute certainty, but there seems no reason to doubt from the condition shown in *fig. 9* that it is as commonly found in the Angiosperms.

In the ripe embryo sac the large egg and the two smaller per-

sistent synergids have well-marked cell walls (*fig. 10*). The large endosperm nucleus is found in a considerable mass of protoplasm, usually near the middle of the embryo sac (*fig. 10, espn*). The distinct antipodals early become sunken in the very bottom of the embryo sac. They seem never to increase in number nor greatly in size, but persist, though slightly crushed, even in the ripe seed (*figs. 12, 13, 14*). During the ripening of the embryo sac it continues to broaden, and when the endosperm begins to form it is nearly globular (*fig. 13*), and in the ripe seed it may be even broader than long (*fig. 14*).

No clear evidence of fertilization or even of the penetration of the pollen tube to the embryo sac has been obtained. Many pollen grains were found on the stigma, some of which had evidently begun to germinate.

In the further development of the embryo sac the endosperm nucleus is at first most active. This nucleus divides repeatedly by mitosis. The daughter nuclei become distributed throughout the peripheral cytoplasmic layer of the embryo sac (*fig. 12*), and after twenty or more free nuclei have been formed cell-walls appear between and about these, and a peripheral layer of cellular endosperm is formed (*fig. 13*). Later the central vacuole is filled up with endosperm cells (*fig. 14*), probably by the division of those of the peripheral layer, since no free nuclei were discovered in the vacuole within the first layer of endosperm cells formed. In the ripe seed the endosperm forms a somewhat top-shaped mass of several hundreds of cells (*fig. 14*).

During this development of the endosperm the egg changes but little except in size at first (*figs. 10, 12, 13*), but later it divides up to form a globular embryo, which in the oldest seeds seen (probably ripe ones) consisted in longitudinal section of thirty or forty cells, and showed no differentiation save a slightly developed suspensor (*fig. 14*).

The synergids, like the antipodals, are long persistent (*figs. 12, 13*), though the former were not seen in the ripe seed.

In the mature seed the embryo is about 0.06 mm in diameter, the endosperm is 0.3 mm, and the whole seed from micropyle to basal wall 1.7 mm long by 1.2 mm broad in the middle.

The contents of the cells of the embryo in the seed seem to be chiefly protoplasmic. The cells of the endosperm possess large nuclei and are filled around this with a substance evidently chiefly proteid in nature, and probably similar in function to that to be mentioned in Heckeria and Peperomia. From the time the eight-nucleate embryo sac is formed the nucellus swells rapidly, and by the time the endosperm-nucleus begins to divide the cells of the nucellus are beginning to fill up with starch. In the ripe seed the cells of the nucellus are solidly packed with starch (*figs. 14, 15, psp*), except the cells near the micropyle and those of the peripheral layer of the nucellus generally, in which the starch grains are smaller and there is a somewhat larger proportion of protoplasmic contents. The crushed and distorted nuclei of the starch-filled perisperm cells are distinguishable even in the mature seed.

No seeds of this species capable of germination were available, but it is natural to suppose that the process of sprouting must resemble closely that to be described in Heckeria and Peperomia, in which genera the structure of the ripe seed is essentially that just described.

II. THE DEVELOPMENT AND GERMINATION OF THE SEED OF HECKERIA.

Material of both *H. umbellata* and *H. peltata* was available, but a complete study was made of the former only.

The ovary of this form arises as a ring-like outgrowth of the axis of the spike above a slightly peltate bract (*fig. 16*), and between the two stamens, which appear somewhat earlier than the carpels. The edges of this ring soon become three-lobed, probably indicating the presence of three carpels in the ovary; and as the walls of the ovary close in above, each lobe stretches out to form a somewhat elongated division of the stigma (*figs. 22, 24, st*). From the time the carpels close in above the ovule until the fruit is ripe, there are found scattered through the carpellary tissue oil-secreting cells, the protoplasts and nuclei of which remain active until a very late stage of development (*figs. 17, 22, 24, oc*). In the mature fruit these are still present and

completely filled with globules of an oily or waxy substance. The stigmas of the ripe fruit are much shrunken (*fig. 29*). The walls of the ovary near the base of the ripe fruit are of six or eight cells in thickness, the cells being generally elongated with the axis of the fruit but not clearly differentiated into layers as in *Piper medium*. The inner cell-wall of the inner layer becomes irregularly thickened with granular material, as in the case of *Peperomia pellucida*. About the upper end of the seed the tissue of the carpels becomes thickened to a mass of rather loosely packed, thin-walled parenchyma cells with oil-cells scattered among them. There are no definite vascular bundles above the very base of the fruit, but scattered tracheids occur, especially in the region just below the stigma. The outer cell-walls of the epidermal layer of the ovary are finely granulated. The hairs which occur abundantly on the bracts (*fig. 16*) are wanting on the ovary. The nucellus of the ovule arises in a strictly basal position, at about the time the walls of the ovary are closing together above. The single hypodermal archesporial cell is distinguishable somewhat later, and is undivided up to the time when the integuments appear (*fig. 17, arsp*). A tapetal cell and the definitive archesporial cell are formed in the ordinary manner (*fig. 18*), and before the integuments have closed above the nucellus the tapetal cell divides to two or three layers (*fig. 19, tp*), which persist in the ripe seed (*figs. 23, 27, 29*).

The two integuments arise in the usual way, and nearly simultaneously, from the base of the nucellus (*figs. 17, 18*). The outer integument develops far enough to close in above the inner (*figs. 19, 22*), and becomes two or three cells thick, but only the inner walls of the inner layer ever thicken greatly, and in the mature seed only the inner layer of cells of this integument is distinguishable, the outer layer being crushed against the surrounding carpellary tissue. The inner integument closes to a narrow micropyle, the cells of which finally grow over to interlock closely from opposite sides (*fig. 27*). This integument soon becomes three-layered, or it may become six-layered above, and in the ripe seed the walls of all these layers of cells become thickened and brown to form the principal seed coat.

The inner layer is made up of radially elongated, prismatic cells, the middle layer of periclinally expanded ones, and the outer of more or less cubical cells (*figs. 24, 25, 27*).

The mature seed is distinctly triangular in transverse section, but the surface of the fruit may be five or six-angled from the pressure of adjacent fruits upon each other in the closely packed spike.

The definitive archesporial cell gives rise immediately to a single megaspore, no indication of degenerating sister megaspores being seen (*figs. 19, 20, 21*). This single megaspore, after enlarging slightly, gives rise to two, four, and finally eight nuclei in the typical manner (*figs. 20, 21, 23*). The large egg and the two synergids, all with distinct cell-walls, occupy the upper end of the elongated embryo sac. The polar nuclei fuse to form a large endosperm-nucleus (*figs. 23, 25*), which may be located near either the base, middle, or upper end of the embryo sac. The antipodal nuclei collect at the extreme base of the sac and do not develop cell walls until somewhat later than the egg and synergids (*figs. 23, 25*).

At about the time of fusion of the polar nuclei the embryo sac ceases to elongate and begins to broaden rapidly, so that the mature embryo sac is nearly spherical in form (*fig. 25*). At this stage the egg and synergids are somewhat flattened against the upper end of the embryo sac, and the very large antipodals bulge into the cavity of the sac from below (*figs. 24, 25*).

As in the case of *Piper medium* mentioned above, the synergids and antipodals are long persistent (*figs. 26, 27*), though apparently not quite so long as in the latter genus. The number of antipodals found below the endosperm mass in the nearly ripe seed is frequently but three; sometimes, however, there may be as many as six or eight (*fig. 28*), which probably arise by the division of the three primary ones, after their cell walls are formed. The prominence of the antipodals here suggests that their function is an important one. They are placed at the base of the embryo sac, in what is probably the direct line of food transit to the sac, and perhaps play a part in the transmission or possibly in the elaboration also of this food material, though the

shape of the older embryo sac seems to indicate that their power of breaking down and absorbing surrounding tissues is not as great as in many other known cases.

The embryo sac becomes filled with cellular endosperm before the egg divides (*fig. 26*). The very first division of the endosperm nucleus has not been seen, but when four nuclei have been formed these are found to be separated by cell walls, so that I believe that a cell wall is formed immediately after the first and each succeeding division of the endosperm nucleus, and thus the endosperm is cellular from the very first. This feature of the development at once recalls the case of *Peperomia pellucida* (Johnson, 1900[a]), but differs strikingly from that of the more closely related genus Piper, as described above. Similar marked differences in the mode of formation of the endosperm in closely related genera have been already noted by Hofmeister (1859, p. 555 *et seq.*), and Hegelmaier (1885, p. 92). Evidently peculiarities of this sort cannot be taken as adequate indications of relationship, as has been recently suggested by Cook (1902) in the case of Nymphaea and Sagittaria.

The cells of the endosperm of Heckeria are at first largely vacuolated and possess large nuclei. The first cell-walls formed radiate from the egg (*fig. 26*), but later the walls come in somewhat irregularly (*figs. 27, 28*). In the ripe seed there are two hundred or more endosperm cells surrounding the embryo, in from two to five layers, and occupying a broadly top-shaped space at the upper end of the seed (*fig. 29*). The vacuoles of the endosperm cells at this time are filled closely with proteid granules, except some of the cells near the embryo, which have but little contents.

The first division of the egg occurs some time after the formation of endosperm begins, whether in consequence of fertilization or not has not been made out with certainty. The direction of the first wall in the few cases seen is oblique, and the arrangement of the cells in the many older embryos seen make it certain that this is the general rule (*figs. 27, 28.*) In the ripe seed the embryo consists of several hundreds of small elongated cells, making a globular mass about 0.05[mm] in diameter, undifferen-

tiated except for a slight projection above, which perhaps is a secondarily developed, rudimentary suspensor (*fig. 29*). As the embryo pushes down into the endosperm the latter seems to close in above so that the embryo often comes to lie nearly centrally in the endosperm.

The germination of the seed in *Heckeria umbellata* (*figs. 30, 31*) is essentially like that of *Peperomia pellucida*, and will be mentioned in connection with the discussion of this process in the latter genus.

III. THE GERMINATION OF THE SEEDS OF PEPEROMIA AND HECKERIA.

The ripe fruit of *Peperomia pellucida* is oval in form, with a slightly pointed upper end, being about 0.85^{mm} long and 0.6^{mm} wide. It is made up, beside the seed, of four or five layers of carpellary tissue. The outer or epidermal layer is made up of bulging, thin-walled cells interspersed with knob-like glandular hairs, perhaps hydathodes in function (*fig. 32.*) The inner layer of the ovary-wall is of very large cells, with coarsely reticulate outer walls and with the basal walls irregularly thickened with granular material (*figs. 32, 33*). Between this layer and the epidermis are two or three layers of delicate, flattened cells.

The seed proper is 0.6^{mm} long and 0.45^{mm} in transverse diameter. It is surrounded by a single integument, the two cell-layers of which have their walls thickened and of a very dark color. The inner walls of the outer layer of the integument fit against the cells of the perisperm, especially at the upper end of the seed, with a very wavy outline (*figs. 32, 33*). In an earlier paper (Johnson, 1900[a], *fig. 15*) I was misled, by the much more regular line of cell-walls separating the outer layer of perisperm cells from those within, into thinking this the line of separation between integument and perisperm. The interpretation given above is however the correct one, as has been shown by Campbell (1901, p. 3), and the lower index line from *int* in the *figure 15* referred to above should run only to the inner, wavy border of the inner of the two darkly shaded cell-layers. All of the cells represented as containing starch in this figure belong to the perisperm. The great bulk of the seed within the integuments is

made up of nucellar tissue, or perisperm, richly stored with starch (*fig. 32*), the grains of starch in the outer cells being finer and less abundant than in the inner ones.

Near the upper end of this perisperm mass, separated from the integument by but two or three layers of cells, lies the somewhat oblately spheroidal mass of endosperm (*fig. 32*). This mass is 0.09^{mm} to 0.1^{mm} in diameter, and is made up of forty or more cubical cells with darkly staining contents, including abundant aleurone grains (Johnson, 1900[a], *fig. 13*).

The embryo is rounded or slightly elongated, without a well-marked suspensor or other sign of differentiation, and lies at the upper border of the endosperm (*fig. 32*). It is surrounded laterally and below by one or two layers of endosperm. It is 0.035^{mm} to 0.04^{mm} long, and is made up of about fifteen cells.

In many sections of the ripe seed a group of cells, corresponding in position to a synergid, is found near the upper end of the embryo, and seems entirely distinct from the endosperm (Johnson, 1900[a], p. 6). Observations made thus far fail to show anything peculiar in the fate of this group of cells during germination. These cells and the six other peripheral cells outside the endosperm (Johnson, 1900[a], *fig. 13*) are soon crushed aside by the swelling of the latter in sprouting.

Seeds of *Peperomia pellucida* collected in Jamaica in August 1900 germinated readily in October of that year. They therefore do not need this long rest apparently necessary for the seeds of *Saururus cernuus* (Johnson, 1900[b], p. 369). The exact course of development, that is the time of ripening and the length of rest required by the seed under the normal conditions, must of course be followed out in the tropics. In Baltimore the behavior of the seeds is as described below, when allowed to germinate on wet filter paper or chopped Sphagnum, at a temperature of 15° to 20°, before an unshaded window, but not in direct sunlight.

No external change whatever is visible in the seed for about a week, except an immediate slight swelling of the carpellary tissue, but important changes are going on within. The embryo grows to 0.1^{mm} in diameter, remaining globular in shape, and is

at this time made up of two hundred and fifty cells or more (*fig. 33*). The endosperm cells divide actively, chiefly by anticlines, swelling meanwhile to encroach upon the perisperm, and upon reaching a diameter of 0.3^{mm} begin to burst the integument near the micropylar end, but remain as a complete sac about the embryo (*fig. 34*).

As germination continues the embryo elongates, the two cotyledons form below, and the primary vascular strand of the hypocotyl appears (*fig. 35*). The endosperm uses up the contents of the surrounding perisperm cells, crushing in their walls at first, and then pushes out above between the rent edges of the integument and carpel (*fig. 35*). In so doing it either pushes aside or carries up with it the persistent group of tapetal cells and the overlying stigmatic regions of the carpel. The embryo remains enclosed within the endosperm sac until it is 0.5^{mm} long or more, at which time the cotyledons are 0.15^{mm} or 0.2^{mm} long, and have each a rudimentary vascular bundle connecting with that of the hypocotyl.

Soon after this size is reached the rapid elongation of the embryo pushes at first the tip and then the whole of the radicle through the upper part of the sac of endosperm (*fig. 36*). Still later by the elongation of the cotyledons all but the tips of the latter are pushed out of the endosperm (*fig. 37*). A swelling of the radicle, somewhat below the middle, first indicates the limits of root and hypocotyl. Below this root hairs soon appear abundantly, and later secondary lateral roots (*figs. 37, 39*). Above on the hypocotyl and cotyledons, even while the latter are still enclosed by the endosperm, numerous glandular hairs and many stomata are formed (*figs. 37, 38*). Within the cotyledons between the vascular bundle and the upper surface of the leaf there is found at this stage a single layer of cells with darkly staining contents whose exact nature and function are as yet undetermined (*fig. 38*).

As the root of the seedling elongates it curves downward to enter and anchor itself in the substratum by numerous root hairs and secondary roots. Then the hypocotyl elongates and thus raises the cotyledons with the adhering endosperm in the air

(*fig. 37*). The endosperm at this time is closely in contact with the tips of the cotyledons and even forces its way in between them somewhat (*figs. 35, 36*). At the outer or upper part of the endosperm it is somewhat thickened and forms thus a collar which tightly grasps the tips of the cotyledons and fills completely the rent in the seed-coat (*figs. 37, 38, esp*). This collar evidently serves not only to hold the seed on the tips of the cotyledons, but also to prevent the exit and loss of any dissolved food material on its passage between the perisperm and the embryo. This collar must also prevent pretty effectually the entrance of water from without to dilute this food material, or of bacteria and fungi to destroy it. The walls of the endosperm cells are comparatively thin throughout, and no indication of thinner spots in their walls or those of the cells of the cotyledons was seen.

The endosperm cap, pushed on by the swelling cotyledons, finally crushes in the previously emptied perisperm cells, until it fills about half the bulk of the seed. After this the absorption may go on until practically all the starch is removed from the remaining perisperm cells, while the walls of these cells remain distended just as when full of food material (*figs. 36, 38*). When the seedling is about 15^{mm} high, the starch of the perisperm being then nearly exhausted, the wasted remains of the seed and fruit slip off from the tips of the cotyledons. Then the curve in the hypocotyl straightens out, and the cotyledons open out widely to allow the still very small plumule to develop and expand (*fig. 39*). During the transference of the starch from the perisperm to the embryo, cells of the former can be seen in which the end near the endosperm is nearly devoid of contents, except for a faintly staining, apparently slimy substance, while the opposite end is still closely packed with starch grains. The chemical changes taking place during this process and the exact mode of transmission have not been made out satisfactorily as yet, but it is hoped that these may be followed out in detail as soon as a supply of fresh seeds can be obtained.

The ripe seed of *Heckeria umbellata* differs from that of *Peperomia pellucida* somewhat in shape and size (*figs. 29, 32*), but

chiefly, for our present purpose, in the considerably more massive embryo of the former. This is however still undifferentiated except for the slightly developed suspensor (*fig. 29*). The process of germination is also practically identical in both species, except that the embryo becomes slightly more differentiated in Heckeria before bursting through the endosperm (*figs. 30, 31, 34, 37, 38*).

The point of chief interest in the germination of these genera, in addition to the deferring of the formation of the organs of the embryo to the time of germination, is the behavior of the scanty endosperm. The endosperm of Peperomia and Heckeria does not at any time during its development contain any considerable amount of starch, though a few scattered grains may appear in it during germination. These latter are perhaps portions of the carbohydrate which are temporarily fixed in solid form during transmission through the endosperm. The cells of this tissue in the ripe seed are pretty rich in protoplasmic contents, with large nuclei (Johnson, 1900[a], *fig. 13*), and the vacuoles are filled closely with aleurone grains. These facts suggest that the chief function of the endosperm in these genera is not the storage of ordinary reserve food material, as this function is served in these seeds by the perisperm. The later history of the endosperm here indicates, though absolute proof must come from careful chemical work, that it really serves as a digestive apparatus for breaking down and absorbing the material stored in the surrounding perisperm and passing it on to the embryo. If this interpretation is the correct one, then the endosperm here fulfills the function which in many other seeds is performed by a part of the embryo itself, as for example the scutellum of the grasses (Haberlandt, 1896, p. 212). The aleurone and denser protoplasmic contents of the endosperm cells gradually disappear as germination proceeds, but the cell-walls remain plump and uncrushed till a comparatively late period of development, except a few cells of the inner layer near the tips of the cotyledons (*figs. 36, 38*). The fact that the cell-contents disappear first from the inner layer of the endosperm might suggest that this material goes directly to the embryo, but it seems quite

as possible that it may pass to the outer layer and thus keep this in condition to continue the absorption of starch from the perisperm. Only a careful chemical study of the cell-contents of all these tissues during the progress of germination can decide these questions definitely.

The restriction of the functions of the endosperm to the passing on, during germination, of the food material without to the embryo within has, so far as I have been able to learn, been pointed out in *Saururus cernuus* only (Johnson, 1900[b], p. 370). Humphrey (1896, p. 16) suggested that the single, aleurone-containing layer of endosperm in Canna might have some such function, but did not follow this out in germination. In the germinating seeds of Canna I find that this layer of endosperm persists till a late stage of this process as a sac about the haustorium, the relation being such that material from the perisperm must pass through the endosperm to get to the embryo, and it seems probable that it may play the same part as that suggested in Peperomia and Heckeria.

In many other families it has been shown, by Hartz (1885) and others, that the storage tissue in the seed outside the embryo is perisperm, and not endosperm, as stated in the older (and many of the newer) books. This is true, for example, of the Polygonaceae, Chenopodiaceae, Phytolaccaceae, Caryophyllaceae, and others, and, contrary to the accepted authorities, there is present in a considerable number of these forms that I have studied a small amount of endosperm also. In all cases of these perisperm-containing seeds which were sprouted, the endosperm was found to persist for some time during germination, and thus to be capable of taking part in the transference of food material to the embryo.

Observations thus far made lead me to believe that in the perisperm-containing seeds mentioned the embryo sporophyte of the second generation is never nourished by the parent sporophyte directly, but always through the intermediate gametophyte. In general, then, we find that the food substance supplied to the embryo by the nucellus may pass through the endosperm and be stored in the embryo during the ripening of the seed, as in

Cucurbita and Phaseolus; or secondly, the food may be stopped in transit between the nucellus and the embryo, and stored in the endosperm, there to be held during the resting period of the seed, and delivered over to the embryo only at the time of sprouting, as in Ricinus, Zea, and apparently all Gymnosperms; or finally, the food supply for the developing embryo may be stored in the nucellus itself until the time of germination, when it is passed on to the embryo through the endosperm, as in Saururus, Peperomia, Phytolacca, Canna, and others.

IV. SUMMARY AND CONCLUSIONS.

Campbell has shown (1899, p. 453) that the nearly ripe embryo sac of *Peperomia pellucida* differs from that of all other Angiosperms studied up to that time in the presence of sixteen free nuclei derived from the megaspore nucleus. The writer found the same species to be peculiar also in the formation of the endosperm nucleus by the fusion of eight of these embryo sac nuclei, and in the persistence of seven others of these near the wall of the sac, one of them near the egg in the position of a synergid (Johnson, 1900[a], p. 4). The ripe seed has a single integument, contains an undifferentiated embryo of about fifteen cells surrounded by a very small endosperm, which is cellular from the two-nucleate stage on, contains chiefly aleurone, and is surrounded in turn by an abundant perisperm stored with starch.

The study of several other species of Peperomia by Campbell and the writer has shown that these agree with *P. pellucida* in the features noted.

The development of the ovary, ovule, and embryo sac in Piper and Heckeria differ widely in several respects from that found in the related genus Peperomia. The ovary in both genera seems to be syncarpous. Two integuments are found in both. A tapetal cell and a single megaspore are formed from the archesporial cell in each genus. The megaspore gives rise in the usual way to a seven-nucleate embryo sac. The antipodals and synergids are long-persistent. The embryo in the ripe seed is very small, of forty or more cells in cross section, and globular except for a very short suspensor.

The endosperm-nucleus of Piper divides to twenty or more free nuclei, and then simultaneously cell-walls are formed about all of these. In Heckeria the endosperm-nuclei are separated from the beginning by cell-walls. Both genera resemble Peperomia in that the endosperm is comparatively slight in amount in the ripe seed and contains no starch, an abundant supply of the latter being stored in the surrounding perisperm.

In the germination of Peperomia and Heckeria the swelling of the endosperm and embryo bursts the seed-coats, and the endosperm protrudes through the rent as a sac which continues to surround the embryo until after root and cotyledons are differentiated. The embryo is truly dicotyledonous. The root finally pushes out through the endosperm, but the latter remains about the tips of the cotyledons and imbedded in the seed till all the starch of the perisperm is absorbed.

The present studies have failed to show, in close relatives of Peperomia, any peculiarities in the development of the embryo sac which are clearly intermediate between that found in this genus and that of typical Angiosperms.

The striking differences in the mode of formation of the endosperm in these three related genera shows again, as has been demonstrated by Hofmeister (1859) and Hegelmaier (1885), that characters of this kind are often of no value as indications of relationship.

The position taken by the writer in an earlier paper (Johnson, 1900[a], p. 9), that these peculiarities in Peperomia are secondary, a view supported by Strasburger (1900, p. 293) and Goebel (1901, p. 806), seems still the most reasonable one.

The case of Gunnera, where Schnegg (1902) has shown that the embryo sac contains sixteen or more nuclei, and that the endosperm nucleus is formed by the fusion of eight or ten of these, might at first sight seem to indicate that we have here again the persistence of a character which Campbell believes to be primitive. A consideration of the evidently distant relationship of these genera, however, together with the fact that no other Angiosperm known shows any relic of this supposed primitive type, makes it probable that Peperomia and Gunnera have secondarily and independently developed this type.

As to the systematic position of Peperomia, the writer sees at present no reason to doubt that it is properly placed among the Piperaceae. Whether the Piperales as an order are to be regarded as very primitive forms is not so clear. It is, of course, possible that the absence of floral envelops here is primitive. The presence of perisperm in the seed is a character found in many of the simpler orders of Angiosperms, but it has probably been secondarily acquired, since we find nothing in the higher Pteridophytes or Gymnosperms to suggest that it is primitive. A survey of the Dicotyledons shows that perisperm is at present known in the seeds of Piperales, Aristolochiales, Polygonales, Centrospermae, and Ranales. All of these orders, as has been pointed out by Schimper and Lesquereux, are old geologically, and possibly represent branches of a single stock or phylum of the Dicotyledons (see Bessey, 1897, p. 33). I am inclined to believe, as many of the older systematic writers have held, that the Piperales are much more closely related to the Polygonales than the position assigned them by Engler (1898) indicates.

Within the Piperales it is evident that the flowers of Piper and Heckeria are more complex in structure (probably primitively so) than those of Peperomia. This is indicated by the syncarpous ovary and the presence of two integuments. It is not clear to the writer that Saururus is "distinctly more specialized" than some of these higher Piperaceae, as suggested by Campbell (1901, p. 114), nor that the Saururaceae are derived from the Piperaceae.

The morphological features of the germination of the seed in Peperomia and Heckeria indicate that the aleurone-containing endosperm of these forms acts as a digesting and absorbing apparatus for transferring the starch stored in the perisperm to the embryo.

In several other genera, of the Cannaceae, Polygonaceae, Phytolaccaceae, Caryophyllaceae, and others, a thin layer of endosperm separates perisperm and embryo and seems to serve the function above mentioned. The embryo sporophyte is perhaps everywhere nourished through the gametophyte and not by the parent sporophyte directly.

I am under obligation to Captain J. Donnell Smith for the freest use of his library and herbarium material, and to Mr. W. C. Coker for collecting seeds of Peperomia and Heckeria in Jamaica.

JOHNS HOPKINS UNIVERSITY,
Baltimore.

LIST OF WRITINGS REFERRED TO.

BESSEY, C. E., Phylogeny and taxonomy of the angiosperms. BOT. GAZ. **24**: 145–178. 1897.

CAMPBELL, D. H., Die Entwickelung des Embryosackes von *Peperomia pellucida* Kunth. Ber. Deutsch. Bot. Gesell. **17**: 452–456. *pl. 31*. 1899.

————. The embryo-sac of Peperomia. Annals of Botany **15**: 103–117. *pl. 6*. 1901.

COOK, M. T., Development of the embryo-sac and embryo of *Castalia odorata* and *Nymphaea advena*. Bull. Torr. Bot. Club **29**: 211–220. *pls. 12–13*. 1902.

ENGLER, A., Syllabus der Pflanzenfamilien, pp. 101–115. 1898. [2d ed.]

GOEBEL, K., Organographie der Pflanzen, p. 806. 1901.

HABERLANDT, G., Physiologische Pflanzenanatomie, p. 210. 1896. [2d ed.]

HARTZ, C. O., Landwirthschaftliche Samenkunde. 1885.

HEGELMAIER, F., Untersuchungen ueber die Morphologie des Dikotyledonen-Endosperms. Nov. Act. Acad. Caes. Leop. Car. **49**: 1–104. *pls. 1–5*. 1885.

HOFMEISTER, W., Neue Beiträge zur Kenntniss der Embryobildung der Phanerogamen. Abhandl. Königl. Sächs. Gesell. Wiss. **6**: 535–672. *pls. 1–27*. 1859.

HUMPHREY, J. E., The development of the seed in the Scitamineae. Annals of Botany **10**: 1–40. *pls. 1–4*. 1896.

JOHNSON, D. S., On the endosperm and embryo of *Peperomia pellucida*. BOT. GAZ. **30**: 1–11. *pl. 1*. 1900[a].

————. On the development of *Saururus cernuus*. Bull. Torr. Bot. Club **27**: 365–372. *pl. 23*. 1900[b].

SCHMITZ, F., Die Blüthenentwickelung der Piperaceen. Hanstein Bot. Abhandl. **2**: 1–74. *pls. 1–5*. 1875.

SCHNEGG, H., Beiträge zur Kenntniss der Gattung Gunnera. Flora **90**: 204. *figs. 26–28*. 1902.

STRASBURGER, E., Einige Bemerkungen zur Frage der "doppelten Befruchtung" bei den Angiospermen. Bot. Zeit. **58**: 293. 1900.

EXPLANATION OF PLATES IX–X.

Abbreviations used: *ant*, antipodal; *arsp*, primary archesporial cell; *br*, subtending bract; *cot*, cotyledon; *cp*, carpel; *cp*[1], external layer of carpellary

tissue (including epidermis); *cp*^{2}, middle layer of carpellary tissue; *cp*^{3}, inner layer of the same; *em*, embryo; *es*, embryo sac; *esp*, endosperm; *espn*, endosperm nucleus; *hy*, hydathode; *iin*, inner integument; *in*, integument; *mp*, micropyle; *nc*, nucellus; *o*, ovum or egg; *oc*, oil-containing cell; *oin*, outer integument; *osp*, oospore; *plu*, plumule; *pn*, polar nucleus; *ps*, pollen sac; *psp*, perisperm; *rh*, roothair; *sg*, synergid; *st*, stigma; *sta*, stamen; *sto*, stoma; *tp*, tapetal cells; *vb*, vascular bundle tissue.

All figures are camera drawings, and all are from microtome sections except *figs. 1*, *37*, and *39*.

Figs. 1–15. Piper medium Jacq.

FIG. 1. Superior view of young flower; the stigmas are often three in number. × 30.

FIG. 2. Tranverse section of an ovary slightly younger than that shown in *fig.* 5, showing indications of the three constituent carpels. × 50.

FIG. 3. Longitudinal section of ovule at the beginning of formation of integuments. × 360.

FIG. 4. Similar section after the formation of tapetum. × 360.

FIG. 5. Longitudinal section of ovary when integuments have just closed in at the micropyle. × 50.

FIG. 6. Longitudinal section of ovule from such an ovary. × 360.

FIG. 7. Longitudinal section of a nucellus containing a four-nucleate embryo sac. × 360.

FIG. 8. Similar section at a slightly later stage. × 360.

FIG. 9. A similar section of an eight-nucleate embryo sac. × 360.

FIG. 10. Longitudinal section of a ripe embryo sac; the nuclei of the synergids from the adjoining section shown in dotted lines. × 360.

FIG. 11. Longitudinal section of a nearly full grown fruit. × 30.

FIG. 12. Detail of micropylar region of same, with embryo sac showing multinucleate non-cellular endosperm. × 360.

FIG. 13. Longitudinal section of somewhat older embryo sac, and adjoining portions of nucellus, showing peripheral layer of cellular endosperm; the synergids indicated in dotted lines are from the adjoining section. × 175.

FIG. 14. Longitudinal section of ripe food and seed, showing relative development of embryo, endosperm, and perisperm. × 30.

FIG. 15. Transverse section at about the middle of ripe fruit. × 30.

Figs. 16–31. Heckeria umbellata L.

FIG. 16. Part of longitudinal section of spike, passing through three ovaries and their subtending bracts. × 360.

FIG. 17. Longitudinal section of an older ovary and the enclosed ovule. × 175.

FIG. 18. Longitudinal section of still older ovule showing tapetum. × 360.

FIG. 19. Longitudinal section of still older ovule. × 360.

FIG. 20. Longitudinal section of ovule with four-nucleate embryo sac. × 360.

FIG. 21. Longitudinal section of slightly older ovule. × 360.

FIG. 22. Longitudinal section of fruit with nearly ripe embryo sac. × 125.

FIG. 23. Detail of embryo sac from section shown in last figure. × 360.

FIG. 24. Longitudinal section of fruit with ripe embryo sac. × 50.

FIG. 25. Embryo sac of same, with surrounding portions of nucellus and inner integument; synergids from adjoining section. × 360.

FIG. 26. Longitudinal section of an older embryo sac with a several-celled endosperm. × 360.

FIG. 27. Similar section of still older embryo sac with twelve-celled embryo. × 360.

FIG. 28. Similar section showing six antipodals. × 360.

FIG. 29. Longitudinal section of ripe fruit. × 55.

FIG. 30. Longitudinal section of germinating seed; the perisperm above the dotted line has been exhausted of starch. × 75.

FIG. 31. Similar section at a later stage of germination. × 30.

Figs. 32–39. Peperomia pellucida Kunth.

FIG. 32. Longitudinal section of ripe fruit. × 55.

FIG. 33. Terminal part of a similar section at an early stage of germination. × 175.

FIG. 34. Longitudinal section of same at still later stage, showing tip of integument and carpel burst off by swelling of endosperm and embryo. × 30.

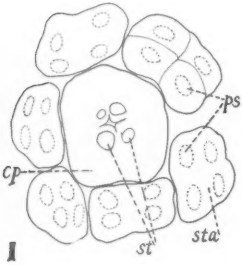
FIG. 35. Detail of embryo and endosperm of same. × 175.

FIG. 36. Longitudinal section of germinating seed (with adhering carpellary tissue), showing radicle pushed out through endosperm. × 55.

FIG. 37. Surface view of seedling with seed about ready to drop from the cotyledons. × 30.

FIG. 38. Detail of same, showing seed and tips of cotyledons. × 50.

FIG. 39. Seedling with expanded cotyledons, showing plumule. × 5.



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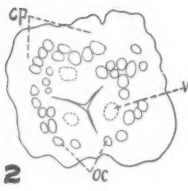

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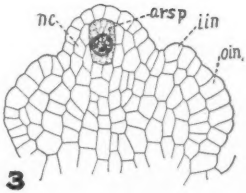

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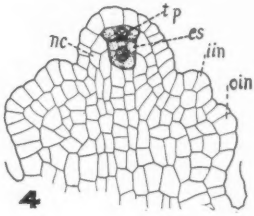

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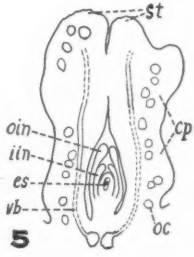

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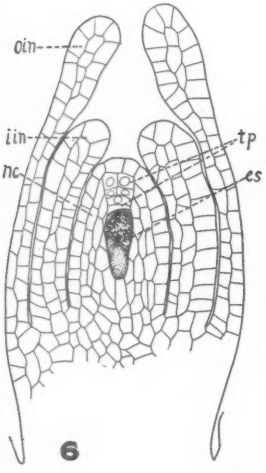

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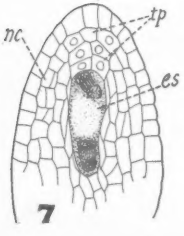

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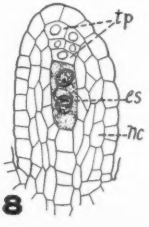

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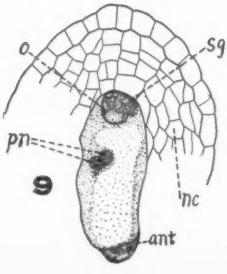

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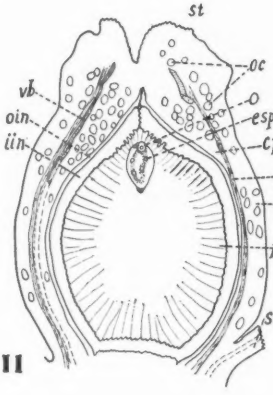

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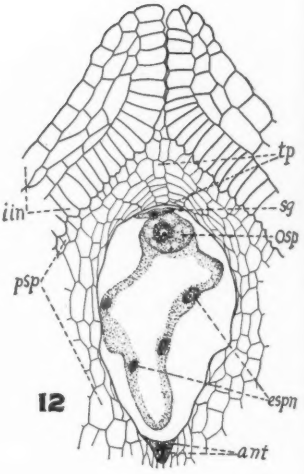

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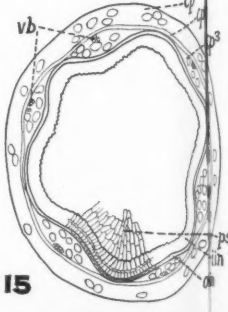

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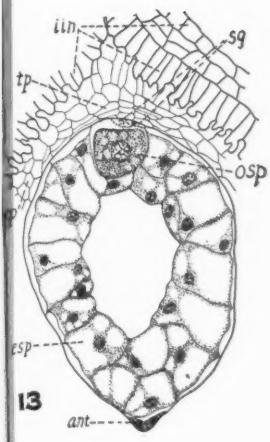

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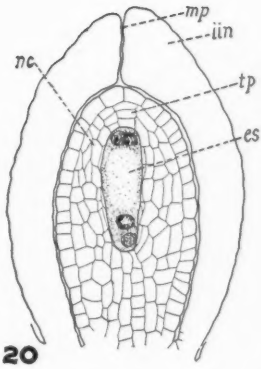

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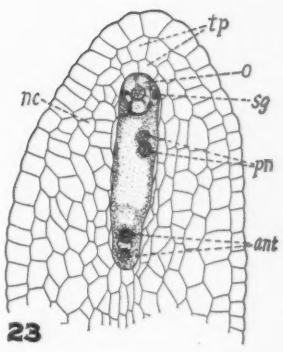

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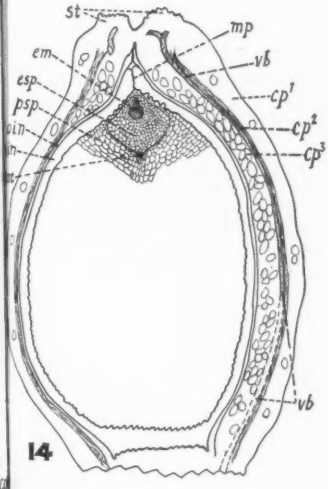

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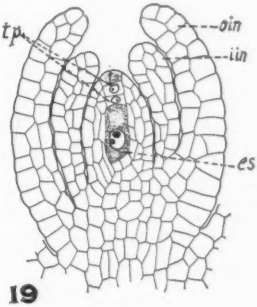

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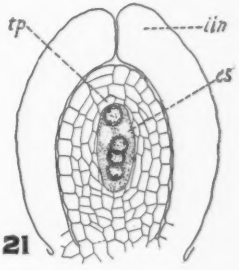

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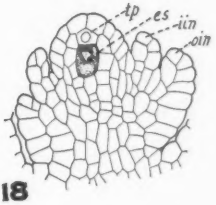

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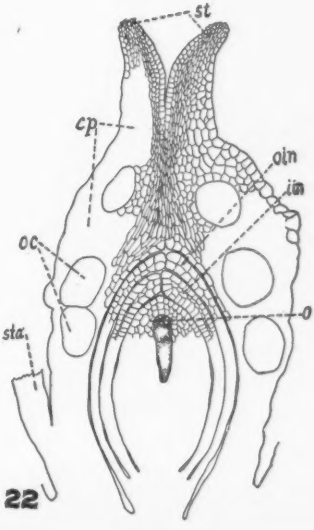

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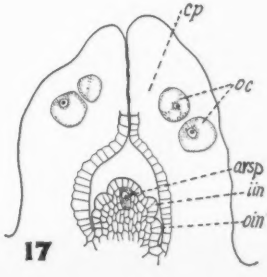

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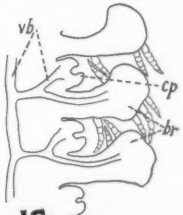

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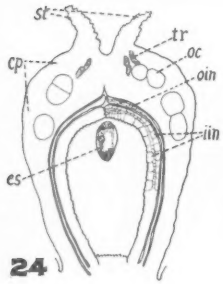

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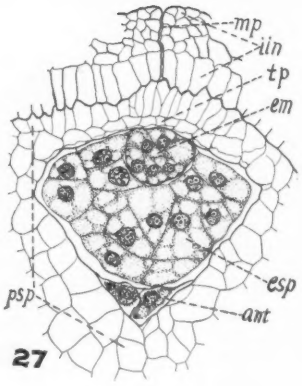

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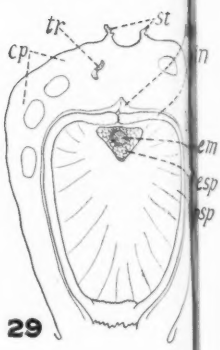

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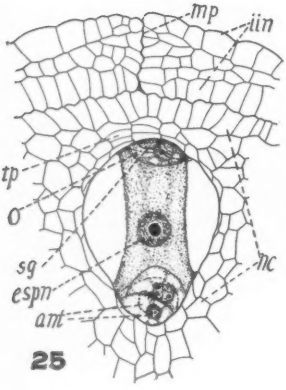

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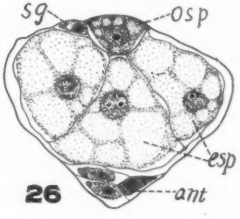

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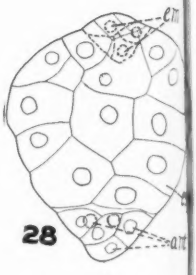

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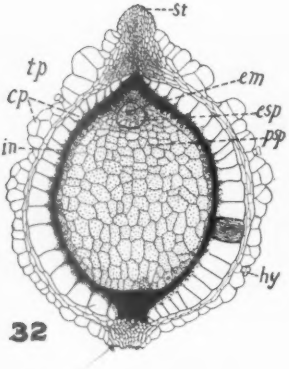

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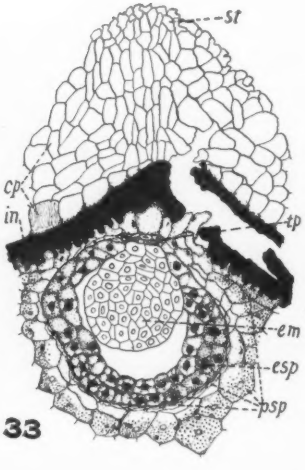

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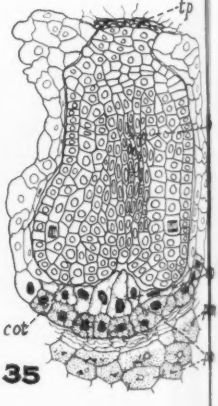

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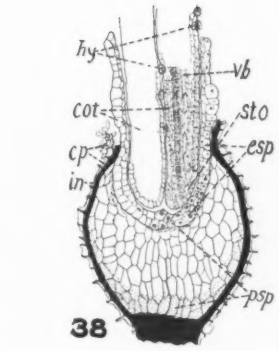

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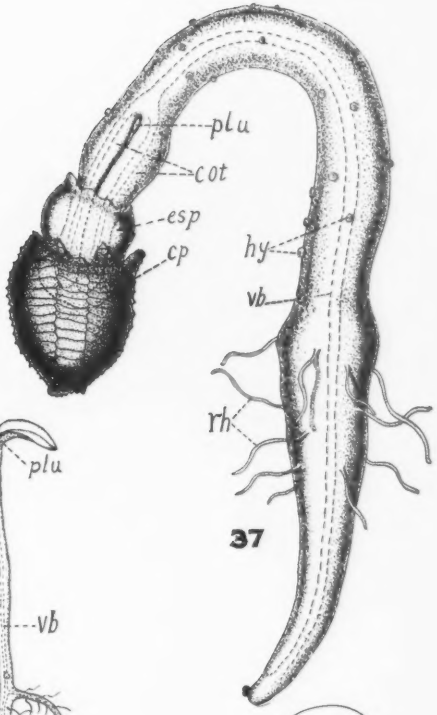

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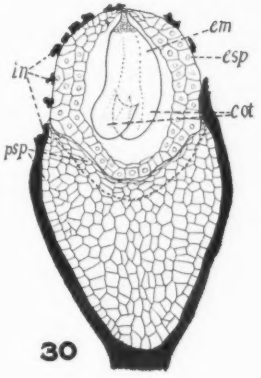

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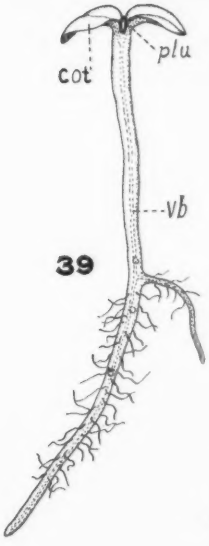

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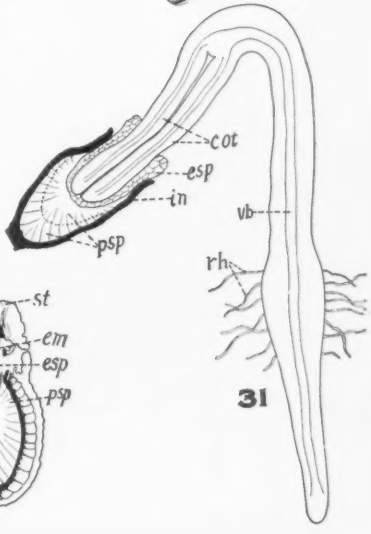

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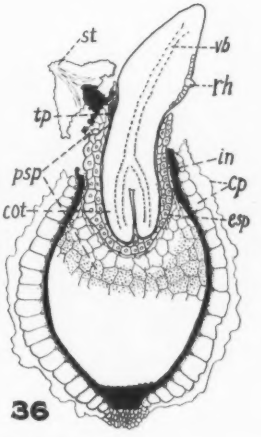

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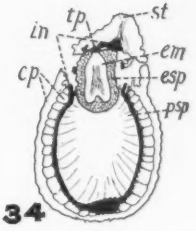


34

THE STRUCTURE OF THE STARCH GRAIN.[1]

HENRY KRAEMER.

(WITH PLATE XI AND TEXT FIGURES)

THERE have been a number of hypotheses advanced to explain the origin, nature, and structure of the starch grain. (1) It was originally considered to be a bubble filled with a liquid, or, as stated by Nägeli, "einer mit Flussigkeit gefüllten Blase." According to Von Mohl, Raspail considered that the starch grain consists "aus einer in Wasser unlöslichen blasenformigen Hülle und einem löslichen gummiartigen Inhalte." (2) Then (1834) it was considered that to a central or excentral point layer after layer was added, the peripheral layers thus being the last formed, this view having been advanced by Fritsche (1) and supported in a more or less modified form by Treviranus (2), Lindley (3), Schleiden (4), Braun (5), Schacht (6), Crüger (7), and Unger (8). (3) Payen (9) in 1838 conceived the idea that growth took place from the outside, that through one or more funnel-like openings at the periphery of the grain new substances entered and new layers were formed therefrom, the outer layers thus being the oldest, in contradistinction to the view advanced by Fritsche. (4) Then followed a series of contributions in which the growth of the starch grain was likened to that of the cell wall and the formation of cells. This theory, with certain modifications, was advocated by Münter (10), Walpers (11), Reissek (12), C. Nägeli (13), Kützing (14), and Hartig (15). (5) While Nägeli (16) recognized that assimilation starch arose in plastids, he considered that most starch grains arose free in the cell sap under the influence of living protoplasm, and it was not until 1880 that Schimper (17) demonstrated that all starch grains develop within plastids and that in the reserve starch grains the leucoplastids finally disappear. Schimper further showed that the outer portion of the grain is the youngest,

[1] An abstract of a preliminary paper on this subject was presented to the Society for Plant Morphology and Physiology, December 1899.

and thus substantiated the view of Fritsche concerning its development.

If we consult any of the standard works on organic chemistry, we find that the formula which is generally accepted for starch is n ($C_6 H_{10} O_5$), this being the formula recognized by Pfeffer, Tollens, and Mylius. It is supposed that the molecular composition is quite complex, the grain being composed of different single groups of $C_6 H_{10} O_5$ or multiples of the same. While this formula may be accepted in a general way, still it has been shown that there are at least two substances which enter into the composition of the starch grain. Nägeli (**16**) has shown that the starch grain consists of two different substances, one which is soluble in ferments, and called by him granulose, and another which is insoluble in saliva, and called by him starch cellulose. He showed that when the starch grain was deprived of its water the lamellae were not apparent, and therefore he concluded that the layering was due to a difference in the amount of water present in the different lamellae. This view has given rise to the formula suggested by W. Nägeli (**18**) for the starch grain, which is $6C_6 H_{10} O_5 + H_2 O$, or $C_{36} H_{62} O_{31}$. Maschke (**25**) considered that the starch grain consisted of alternate layers of cellulose between which starch substance was deposited in two modifications, one soluble in water forming the light-colored lamellae, and another insoluble in water forming the dark layers. This view was not adopted, however, and Nägeli's theory prevailed until 1886, when Arthur Meyer (**19**) demonstrated that the substance termed cellulose by Nägeli, and which was termed "farinose" by Von Mohl (**20**), gave reactions similar to artificially prepared crystals of amylodextrin. In 1895 Meyer (**21**) further considered the composition of the starch grain and stated that it is made up of (1) α–amylose, (2) β–amylose, and (3) amylodextrin, a decomposition product of amylose. He also expressed the opinion that inasmuch as there is an anhydride of dextrose which does not readily take up water, there is probably also an anhydride of amylose which even on boiling with water is hydrated with difficulty, and that this is the substance that has given rise to the belief that there is

present a starch cellulose. This latter term, according to Meyer, has been used for a number of different substances: (1) mixtures of amylodextrin and α–amylose; (2) solutions of α–amylose and β–amylose; (3) solutions of β–amylose with various other substances, as nitrogen-holding substances, impure fatty products, pure amylodextrin, and the walls of plant cells which are contained in commercial starches unless carefully purified. He obtained the α–amylose upon treating starch paste (Stärkekleister) with malt solutions (Malzauszug) and by the action of hot dilute solutions of hydrochloric acid upon the whole starch grain. The portion remaining (β–amylose) is distinguished from the portion dissolved in that it is not soluble in water and becomes slightly reddish, and not blue with iodine.

One of the earliest views in regard to the development of the starch grain was that new layers were added to those previously formed, these being separated from each other by layers of air which were later called "Adhäsionsflächen," "Contactflächen," and "Grenzflächen" by Dippel (**22**), Strasburger (**23**), and Krabbe (**24**) respectively. These terms, however, have been mostly used by these authors in describing the structure of cell walls. In 1858 Nägeli (**16**) advanced the theory that the starch grain consists of elementary particles, later termed by him "micellae," which he supposed to have the form of parallelopipedal prisms with rectangular or rhomboid bases. Furthermore, according to Nägeli, these micellae possess a watery film, are embedded in a mother liquor which differs from them in composition, and are held together by certain forces. The growth of the starch grain is effected by the interpolation of new material among the particles already formed, this new substance being utilized in part in increasing the size of the micellae already formed, and also to form new micellae, which develop and arrange themselves according to the laws which the micellae previously formed have obeyed This theory is known as the "intersusception theory," while the earlier one is spoken of as the "apposition theory." In addition to these two views in regard to the structure of the starch grain, Schimper (**17**) considered that it is made up of sphere-crystals which he called

"Spharokrystalloide." Meyer (21) has enlarged upon this view and considers the starch grain to be made up of two kinds of acicular crystals, which he calls "Trichiten," these being composed of α–amylose and β–amylose, there being also present in the grains that are colored red with iodine, amylodextrin and dextrin. He further says that most starch grains consist altogether or nearly so of amylose, and that these are colored blue with iodine. These latter starch grains are made up of sphere-crystals of amylose, arranged in layers, and these layers may consist of crystals of either α–amylose or β–amylose, or both, some starch grains containing in addition, as already stated, large amounts of amylodextrin and dextrin.

Starch grains are distinguished from one another by the following particulars: (1) The origin in the plant; (2) the shape of the grain; (3) the size of the grain; (4) the position of the point of origin of growth;[2] (5) the shape of the point of origin of growth; (6) distinctness of lamellae; (7) the direction of the lamellae; (8) behavior toward dilute iodine solutions; (9) the temperature at which the "Kleister" or paste is formed and its consistency; (10) the behavior toward various reagents, as chromic acid, calcium nitrate, chlor-zinc-iodide, sulphuric acid, diastase, etc.; (11) the appearance as viewed by polarized light. These differences in starch grains not only from different sources, but even in those of the same origin, tend to show that instead of starch being a uniform substance, it is made up of several substances, these occurring in varying proportions but appearing to be more or less definitely arranged.

The author may briefly state that he conceives the reserve starch grain to be the direct product of the polymerization of soluble carbohydrates of either the glucose or cane sugar group, together with the abstraction of water. This process is carried on under the influence of an organized body — either protoplasm, or a plastid, or both. The products thus formed consist of two

[2] The terms "hilum" and "nucleus" have been employed to distinguish the central or excentral marking, around which the lamellae or layers of the grain are arranged. These terms, however, are open to criticism, inasmuch as they are employed for another and specific purpose. The expression "point of origin of growth" seems to be better on account of its being less confusing, and is moreover descriptive and accurate.

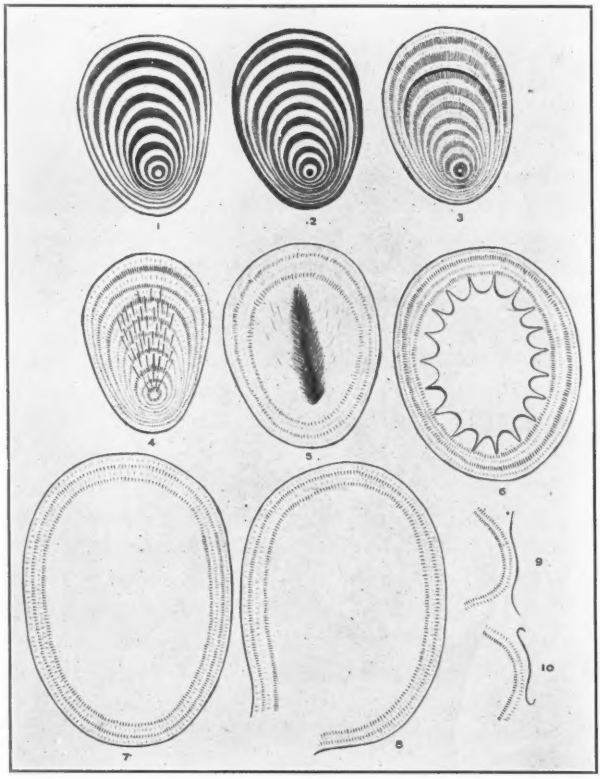
crystalloidal substances, namely starch cellulose[3] and granulose, and also a colloidal substance. These occur as follows: (*a*) In the point of origin of growth we find the colloidal substance associated with a small proportion of cellulose as also in the alternate lamellae; (*b*) in the other layers occurs the granulose associated with a small amount of colloidal substance and possibly also some cellulose; (*c*) the peripheral layer of the grain is not readily acted upon by reagents and is quite elastic and more or less porous, probably consisting of an anhydride of cellulose; (*d*) in some cases some of the dextrins or some of the non-colloidal or crystalline carbohydrates, as maltose, dextrose, levulose, etc., may be present, but these are probably formed as a result of alterations taking place in the grain.

There have been a number of important contributions on the subject of the origin and structure of the starch grain, and while the views of the authors appear to be more or less at variance, still this is not to be wondered at, and it is highly probable that future observations will harmonize some of these conflicting views.

The illustrations of potato starch grains in the different text-books show two kinds of grains, one in which the point of the origin of growth and alternate lamellae are light in color, as figured by Sachs (**26**); and the other in which the corresponding parts are dark in color, as figured by Strasburger (**27**). There is in reality no difference in these grains, this apparent difference being due to the manner of focusing upon them (*figs. 1, 2*), that is, whether viewing the lamellae from above or from below, or, as the Germans would say, by "tiefe oder höhe Einstellung." The two views of the successive lamellae thus obtained may be compared to the appearances obtained with two entirely different substances, the one corresponding to a more or less definite solid substance, as an oil globule, and the other to a body such as an air bubble (or vesicle filled with air or any other gaseous or

[3] Cellulose was a term first applied by Nägeli (**16**) and corresponds to the farninose of Von Mohl (**20**) and probably to the β-amylose of Arthur Meyer (**21**). Granulose another term which is generally accepted to have been coined by Nägeli (**16**), was adopted by Von Mohl (**20**) and apparently corresponds to the α-amylose of Arthur, Meyer (**21**).

rarefied material). The appearance as observed in the oil globule corresponds to that of the layer next to the point of origin of growth and the layers alternating with it. The appearance of



FIGS. 1–10.—Potato starch grains, showing the effect of chromic acid and other reagents.

the air bubble corresponds to that of the point of origin of growth and the layers alternating with it. There is this difference, however, that instead of the purplish hue so characteristic of the air bubble, there is a reddish field in the starch grain which may be taken as indicating that it is of an entirely different

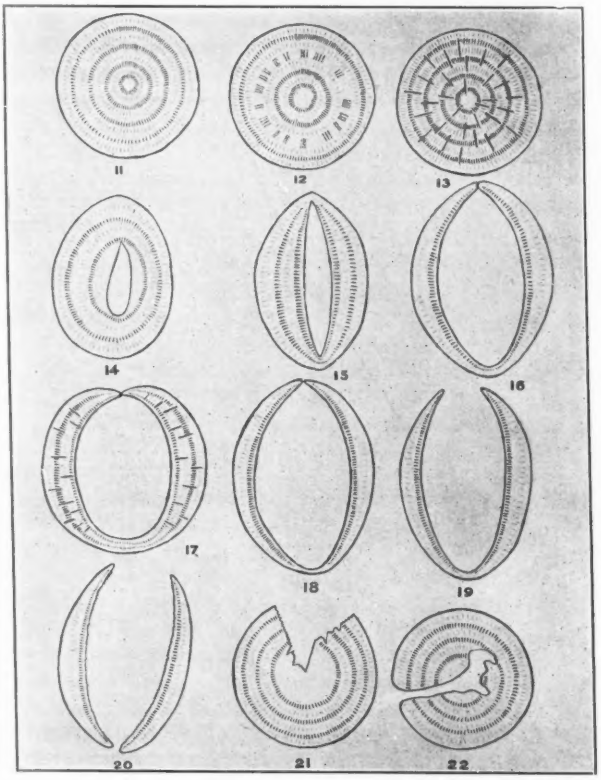
composition. A possible explanation of this phenomenon may be that in the air bubble the violet rays, owing to their length and velocity, completely overshadow the red rays; whereas in the starch grain the layers containing other substances offer a resistance to and refract the violet rays and leave the red only in view. As a result of this physical examination of the grain we observe that the successive layers differ in density, and that these correspond to the "water-poor" and "water-rich" lamellae described by Nägeli (**16**).

We further find in some of the potato starch grains that at the periphery of the point of origin of growth, as well as upon the inside of one or more of the layers corresponding to it, there is a dark line much resembling the peripheral layer of the grain (*fig. 3*). This probably led Dippel (**22**), Strasburger (**23**), and Krabbe (**24**), to consider that the lamellae did not differ in character, but that this appearance of lamellation was due to lines of contact, as already stated. Krabbe in the chapter dealing on the "Spiralstreifung der Bastfastern" further distinguishes between "Grenzflächen" and "Contactflächen." He says: "Schichten mit derselben Streifung, jedoch mit verschiedener Steilheit derselben, vorliegen, da wird ihre gegenseitige Abgrenzung dadurch noch deutlicher, das die Grenzflächen der Spiralbänder in der Contactfläche der Schichten nicht immer aufeinander Stossen."

A further evidence that there is a marked difference in the layers of the grain is the effect produced by staining reagents (*figs.* *29, 30*). On treating starch grains with weak aqueous solutions of safranin and gentian-violet,[4] it is observed that certain parts of the grain take up these stains more readily than others. The gentian violet stain is more pronounced in its effect upon the potato starch grain (*fig.* 37), it being held by the point of origin of growth and the lamellae alternating with it. Safranin, on the other hand, is a better differential stain for wheat starch grains (*figs. 36, 39*), being held in certain of the lamellae (usually not more than three or four of them being affected) and in numer-

[4] The method used by the author consisted simply in treating the freshly isolated starch grains, or the commercial starches, with weak aniline dye solutions and allowing them to dry at an ordinary room temperature.

ous radial clefts or channels. Corn starch (*fig.* ~~16~~ 35) does not appear to take up these stains as readily as either wheat starch or potato starch, and there is no differentiation of the lamellae.



FIGS. 11–22.—Wheat starch grains; *11–20*, showing the effect of chromic acid and other swelling reagents; *21–22*, showing a direct disintegration of the grains through the action of ferments.

This is probably due to the peripheral layers being denser and less permeable. Salter (28) in speaking of the staining of the grain says that it is dependent upon the absorption of the aniline dye, and that in no case does it seem to have a selective or

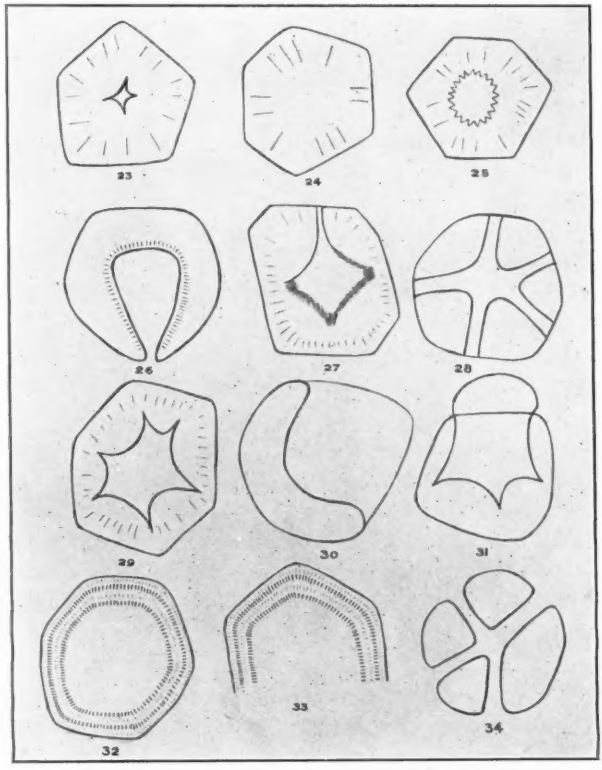
specific action on the layers. The figures of Salter, however, show that the stain is taken up by certain parts of the grain more than others, and in another place he states that "die Lamellen die im frischen Stärkekorn als dunklere Linien erscheinen sind diejenigen welche den Farbstoff am reichlisten einsaugen." In speaking of Meyer's work he goes on to say: "Meyer erwahnt dass bei der Farbung mit Methylviolet der Farbstoff besonders von den weicheren Lamellen beibehalten wird." The only unfortunate thing is that we do not know to what layers these authors refer when they speak of "weicheren Lamellen" and lamellae with "dunklere Linien." There seems to be no doubt, however, that what they have in mind corresponds to my own observations, that is, it is the layers which are colloidal in character which take up the stains; in other words, the point of origin of growth and the layers alternating with it.

Another interesting feature serving to differentiate the layers of the starch grain is the behavior toward dilute iodine solutions. The layers which are not affected by the aniline stains become blue with iodine, the alternate layers and the point of origin of growth remaining unaffected. The layers thus affected by iodine are the ones which are rich in granulose and are more clearly defined in the grains of potato and wheat starch than in corn starch. These layers become crystalloidal in character on treatment with water at 60° or 65° C. for about an hour, and also with chromic acid, calcium nitrate, saliva, and other reagents.[5]

The behavior of potato starch toward these reagents may be briefly summarized as follows (*figs. 1–10*): The first effect of the reagent is to make the lamellae more distinct (*figs. 1–2*); this is followed by the development of the crystalloidal character of the lamellae (*fig. 3*), which is most pronounced in those colored blue with iodine; this is followed by the production of small tracts or channels (*fig. 4*) connecting the contiguous lamellae, particularly in the middle of the grain; succeeding this there is the formation of channels which are larger and plume-like in appearance (*fig. 5*), the grain meanwhile swelling quite percep-

[5] Proc. Acad. Nat. Sci. Philadelphia **53**: 450. 1901.

tibly, the middle portion becoming clearer and assuming a zigzag outline (*fig. 6*), between which and the periphery of the grain a number of crystalloidal lamellae arise (*fig. 7*); the



FIGS. 23–34.—Corn starch grains, showing the effect of chromic acid and other swelling reagents.

grain now becomes spherical and marked by a number of concentric lamellae near the periphery; the latter finally ruptures (*fig. 8*) and then follows a gradual solution of the grain, the peripherical layer sometimes recurving like the cutin layer of an epidermal cell on treatment with sulphuric acid (*figs. 9, 10*).

In wheat starch (*figs. 11–22*) the development of the crystalloidal character of the lamellae (*figs. 11, 12*) is followed by the formation of narrow, interrupted or continuous, radial channels near the periphery of the grain (*fig. 13*), which are sometimes connected with lamellae occurring near the middle of the grain; the grain meanwhile swells quite perceptibly, the center becomes clearer (*fig. 14*), the contents are crowded into crescent-shaped halves which are still slightly connected at the poles (*figs. 15–17*); the contents of each of the halves of the grain consist of crystalloidal lamellae in which are then produced small tracts or channels connecting the contiguous lamellae (*fig. 17*); the halves in some instances finally separating and slowly dissolving (*figs. 18–20*). In some cases, on the other hand, there is a corrosion of the grain at the periphery, followed by gradual disintegration without the separation into halves (*figs. 21, 22*).

The first effect of reagents upon the corn starch grain (*figs. 23–34*) is to bring out the point of origin of growth (*fig. 23*), the latter becomes larger and in some cases more or less zigzag (*fig. 25*) in outline; between this and the periphery of the grain arise more or less interrupted or continuous radial channels (usually the latter); the crystalloidal structure of this grain develops slowly and is most pronounced when the grain has swollen to two or three times its normal size; at this stage we find that the center of the grain has become clear and the point of origin of growth has become obliterated in some cases (*fig. 24*), and between it and the periphery occur numerous crystalloidial lamellae similar to those observed in the potato starch; finally the peripheral layer ruptures and there is a gradual disintegration of the grain (*figs. 26, 30, 33*). Sometimes the grain appears to separate into as many parts as there were arms to the point of origin of growth (*figs. 27, 28, 34*), particularly when acted upon by saliva or diastase.

A number of authors since the time of Nägeli have shown that the lamellae of starch grains differ in constitution and structure, and that there are at least two distinct kinds of lamellae. This view is confirmed not only by a microphysical examination of the grain, and by treatment with weak solutions

of iodine and aniline stains, but also by treatment with water and various reagents as just pointed out. Both Salter and Meyer appear to hold to the theory that there is a distribution of crystalloidal substance in particular lamellae. Salter quotes Meyer as saying: "die schattierten Schichten bedeuten die schwach lichtbrechenden relativ lockeren, an fester Substanz relativ armen, an Interstitien reichen Schichten, die hellen sind also die stark lichtbrechenden Schichten aufzufassen, welche die meiste feste Substanz enhalten." Here again it is unfortunate that the descriptions do not enable us to determine which layers are meant. It is likely, however, that the layers described as "schattirten Schichten" are the colloidal layers, and those designated as "hellen Schichten" are the crystalloidal layers.

In summing up the observations herewith presented, we find that the starch grain consists of colloidal and crystalloidal substances, these being arranged for the most part in distinct and separate lamellae, that is, at the point of origin of growth, and in the alternate lamellae the colloidal substance preponderates, associated with the crystalloid cellulose; whereas in the other layers the crystalloidal substance, consisting for the most part of granulose, occurs in greater proportion.

As a further evidence of the presence of these crystalloidal and colloidal areas we may say that the peculiar behavior of the colloidal layers toward aniline stains is analogous to the behavior of a section containing mucilage cells toward these dyes, the latter being taken up by the mucilage cells alone. Furthermore, as the characteristics of mucilage cells are most pronounced in anhydrous media, as concentrated glycerin, so a similar effect is observed in the starch grain, but owing to the action of the glycerin in readily forming soluble starch, the preparations of the starch grain, like that of the cell wall, when thus stained are best preserved in Canada balsam.

The crystalloidal character of certain of the lamellae as observed in connection with the swelling of the grain might be considered to be in the nature of microscopic clefts, but it should be said that we know of no colloid that behaves in this manner, and such an assumption does not seem to be well

founded. Furthermore, this appearance (crystalloidal) might be considered as due to an internal folding of the substance of the lamellae, but this would only arise in case of a contraction or reduction in the area of the lamellae ; but as we have already seen the grain is swollen from two to four times its original size, and even in the fragments of the disintegrating grains the crystalloidal character is pronounced. It seems more likely, as I have already pointed out, that the reason this structure is not apparent under natural conditions is because the refractive properties of the crystalloidal substance so nearly resembles that of the associated colloid. The use of certain reagents, however, which are more or less penetrating in their action, cause an imbibition of water by the colloidal portions with consequent swelling of the grain, and hence a contrast in refractive power with the more insoluble crystalloidal substances.

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LITERATURE CITED.

1. FRITSCHE: Poggendorff's Annalen der Physik und Chemie **32**: 1834.
2. TREVIRANUS: Phys. der Gewächse **2**: 23.
3. LINDLEY: Introduction to Botany, Ed. 3, p. 44.
4. SCHLEIDEN: Grundzüge **3**[1]: 187.
5. BRAUN: Verjüngung, p. 212.
6. SCHACHT: Lehrbuch der Anat. und Phys. der Gewächse **1**: 58.
7. CRÜGER: Bot. Zeit. **10**: 41. 1854.
8. UNGER: Anat. und Phys. der Pflanzen, p. 115.
9. PAYEN: Ann. Sci. Nat. **10**: 5, 65, 161. 1838.
10. MÜNTER: Bot. Zeit. **3**: 197. 1845.
11. WALPERS: Bot. Zeit. **9**: 339. 1851.
12. REISSEK: Flora **5**: 13. 1847.
13. NÄGELI, C.: Zeitschrift für wissenschaftliche Botanik von Schleiden und Nägeli 117. 1847.
14. KÜTZING: Grundzüge der Philos. Bot. **1**: 263.
15. HARTIG, Th.: Bot. Zeit. **13**: 905. 1855 ; **14**: 350. 1856.
16. NÄGELI, C.: Die Stärkekörner. Pflanzenphysiologische Untersuchungen. Zurich. 1858.
17. SCHIMPER: Bot. Zeit **38**: 881. 1880 ; **39**: 185, 201, 217. 1881.
18. NÄGELI, W.: Beiträge zur naheren Kenntniss der Starkegruppe. Munich. 1874.
19. MEYER, A.: Bot. Zeit. **39**: 841–857. 1881 ; **44**: 697, 713. 1886.

20. VON MOHL: Bot Zeit. 17: 226. 1859.

21. MEYER, A.: Untersuchungen über die Stärkekörner. Jena. 1895.

22. DIPPEL: Bot. Zeit. 9: 409. 1851: Abhandl. Senkenb. Gesell. 10: 181.

23. STRASBURGER: Ueber den Bau und das Wachsthum der Zellhäute. Jena. 1882, p. 64; Ueber des Wachsthum vegetabilscher Zellhäute. 1889, p. 147.

24. KRABBE: Jahrb. Wiss. Bot. 18: 346. 1887.

25. MASCHKE: Jour. Prakt. Chem. 56: 400. 1852.

26. SACHS: Lehrbuch der Botanik. Leipzig. 1874.

27. STRASBURGER: Das botanische Praktikum. 1884 and 1887.

28. SALTER: Jahrb. Wiss. Bot. 32: 117. 1898.

29. ROTHERT: Ber. Deutsch. Bot. Gesell. 15: 231.

30. FISCHER: Ueber Inulin, etc. Cohn's Beiträge zur Biologie der Pflanzen 8: 53. 1898.

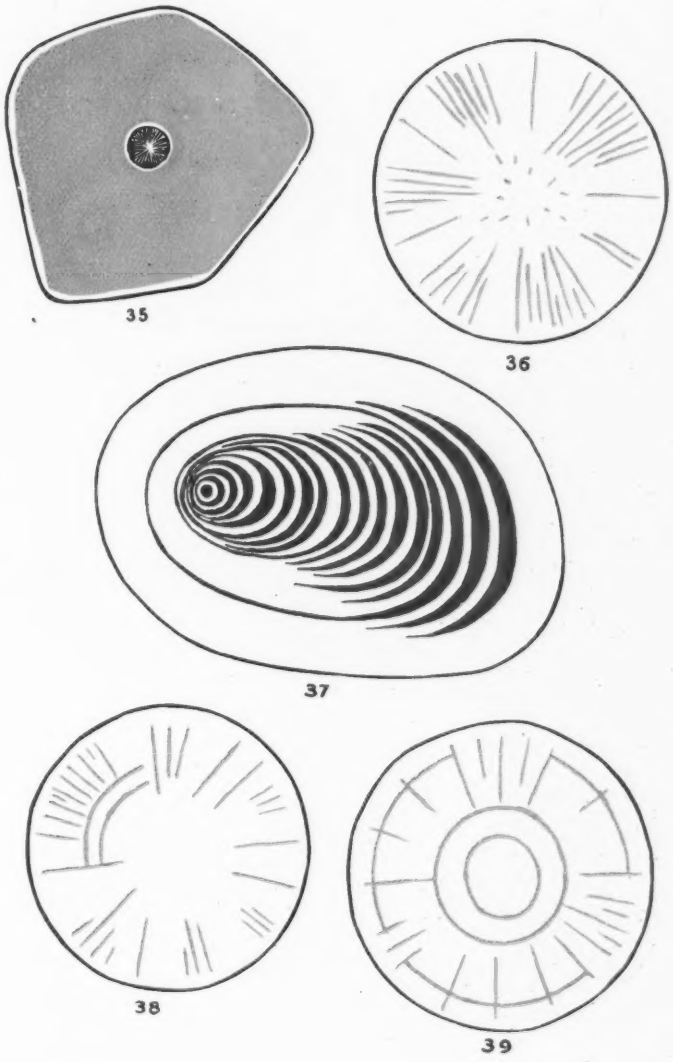
EXPLANATION OF PLATE XI.

FIG. ~~35~~ 37. Potato starch grain treated with weak aqueous solution of gentian-violet.

FIGS. ~~36–39~~ 34, 38, 39. Wheat starch grains treated with weak aqueous solution of safranin.

FIG. ~~40~~ 35. Corn starch grain treated with weak aqueous solution of safranin.

See list of Errata p. vii



KRAEMER on THE STARCH GRAIN

CONTRIBUTIONS FROM THE ROCKY MOUNTAIN HERBARIUM. IV.

AVEN NELSON.

SOME CHENOPODIACEAE.

PROBABLY the most characteristic plants of the great saline plains of the West and the similar basins of the intermountain country are the Chenopodiaceae. Some of the genera in this family are known by name, at least, to most people. Such, for example, are greasewood, the salt-bushes, winter-fat, Russian-thistle, etc. Many of the species in this family are of remarkably wide distribution. As they become better known it is found that the range of some, once supposed to be quite circumscribed, is really quite extended. The strongly alkali-impregnated areas are so inhospitable that most plants are unable to occupy them, and nearly all the members of this family have in some way become tolerant of such soils. So far as the effect upon vegetation is concerned, all of the saline districts are essentially the same, the differences in the soil being apparently one of degree rather than of quality. This fact coupled with another, that this family has little competition on this kind of soil, may account in a measure for the unusually wide range of some of the species. Of course the other factors of environment are operative upon these plants as upon others, but they seem less potent than the soil in producing specific variation.

ATRIPLEX.

The foregoing remarks have been suggested by a rather extended study of certain species of Atriplex occurring within the Rocky mountain region. Not satisfied with the view afforded by the specimens in the Rocky Mountain Herbarium, the loan of another large collection was solicited.[1] Some notes

[1] I wish to express my thanks to Dr. William Trelease, Director of the Missouri Botanical Garden, for the privilege of examining all the specimens illustrating the species considered in this paper which are contained in the Engelmann herbarium and the general herbarium of the Garden.

upon the results of the examination of this material may be of interest, especially since it served, in part, to disclose the new species herein proposed.

ATRIPLEX CANESCENS (Pursh) James, Catalogue 178.—This well known species is strongly marked by its winged fruits, and is more widely distributed than any of the species known to the writer. A very large series of specimens, covering a range extending from the Dakotas to California, show no marked differences, none sufficiently constant to constitute even a geographical form.

Atriplex aptera, n. sp.— Perennial, from a woody base, the annual stems fascicled, decumbent at base or even depressed, more or less branched, 1–3^{dm} high: leaves narrowly oblong, 2–4^{cm} long, 5–8^{mm} broad, mostly obtuse, the base cuneately narrowed to a subsessile base: fruiting spikes paniculate, crowded, bracteate; the bracts linear-lanceolate, gradually reduced upward or wanting: dioecious, only the pistillate plant seen; fruiting bracts united, scarcely stipitate, somewhat indurated, densely scurfy, appendaged with three or four more or less vertical rows of short vertically flattened processes, some of these often expanded but scarcely wing-like.

This is the only species that makes a close approach to *A. canescens.* It is readily distinguished, however, by its smaller size, less woody condition, and the wingless scurfy fruits. *A. canescens* occupies dry clay, chalk, and marl cliffs and ridges; while *A. aptera* occurs (so far as known) on moist saline flats. It is a most excellent forage plant. The type is *Elias Nelson* 738, Laramie, Wyoming, September 1901.

ATRIPLEX HYMENELYTRA (Torr.) Wats. Proc. Am. Acad. 9: 119.—The remarkable fruiting bracts will not permit this species to be confused with any other. From the available specimens it would seem that it does not come into the Rocky mountain region proper, but extends from southern Utah into southern California.

ATRIPLEX CONFERTIFOLIA (Torr.) Wats. Proc. Am. Acad. 9: 119.—This is peculiarly a Rocky mountain plant, but has an extended north and south range, in fact across the United States.

ATRIPLEX ACANTHOCARPA (Torr.) Wats. Proc. Am. Acad.

9 : 117.—Though sometimes attributed to Colorado and Utah, it is doubtful if it comes so far north. The Colorado and Utah plants usually so named may stand as follows :

Atriplex cuneata, n. sp. — Perennial, with woody base, from two to several decimeters high, branched from the base, the branches decumbent : leaves numerous, on the erect branches of the current year, 1–3 ^{cm} long, entire, thick or semi-fleshy, from narrowly to broadly elliptic, obtuse at apex, cuneately tapering into a short petiole : flowers dioecious ; the staminate densely clustered in the upper leaf axils and in terminal spikes ; the pistillate axillary, one or more in each cluster : fruiting bracts united except at the tip, thickened and forming an ovate or subglobose fruit, rather thickly covered with irregular, rigid, flattened processes.

This species is closely allied to *A. acanthocarpa* (Torr.) Wats., in fact is probably included, in part, in Watson's description (Proc. Am. Acad. 9 : 117). It is probably not a part of *Obione acanthocarpa* Torr. Bot. Mex. Bound. 183. In any case, we must consider the typical form of that species as erect ; the leaves thin, undulate margined, oblong or lanceolate, usually acute and many of them subhastate. Excellent specimens of typical *A. acanthocarpa* and of the now proposed species show marked differences in many respects, which will account for the fact that the latter has as often been distributed as *A. Nuttallii* as under the former name. Its range seems to be from western Colorado into Utah and south to New Mexico and Arizona.

SPECIMENS EXAMINED : *Chas. Wright* 573, expedition of 1849 ; *Brandegee* 1086, S. W. Colorado, 1875, in the Hayden Survey ; *Alice Eastwood*, Grand Junction, Colorado, 1891 ; *M. E. Jones* 5443, Emery, Utah, 1894 (type, in Rocky Mt. Herb.); *Baker*, *Earle*, and *Tracy* 420, Mancos, Colorado, 1898 ; *Myrtle Zuck*, Holbrook, Arizona, 1896.

ATRIPLEX NUTTALLII Wats. Proc. Am. Acad. 9 : 116.—This is preeminently the characteristic saltbush of the Rocky mountain plains. It is not so tolerant of alkali as most of the other species, some of which always replace it in strongly saline areas. It is a most valuable forage plant, surpassed in quality, but not in quantity, only by the following :

ATRIPLEX PABULARIS Aven Nelson, Bull. Torr. Bot. Club 25 : 203.—The known range of this well marked species is being gradually extended. It has been found now in several of the saline districts of Wyoming and will no doubt be found elsewhere.

ATRIPLEX EREMICOLA G. E. O., Bull. Torr. Bot. Club **25**:284, is very closely allied to the preceding, distinguished principally by a more branched, woody, and decumbent base.[2] It may have to take varietal or even lower rank.

ATRIPLEX EXPANSA Wats. Proc. Am. Acad. **9**: 116.—A very large part of the specimens found under this name are quite distinct from typical *A. expansa*. In the collections of the Missouri Botanical Garden only two were found to be true *A. expansa*, while there were several which are now named as below. The typical form apparently extends westward from New Mexico on either side of the "boundary." It is a much larger plant, "growing in intricately entangled masses 6–10 feet in diameter and 4–6 feet high." Stems and branches have fairly long internodes, the spikes interrupted, leafless toward the apex.

Atriplex philonitra, n. sp.—Annual, silvery-white, with a dense scurfiness, freely branched throughout, widely spreading and forming low tangled masses, 2–4 ^{dm} high: leaves in young plants from broadly ovate to orbicular, 3-nerved, 1–3 ^{cm} long, on petioles mostly exceeding the leaves; in older plants very numerous, rhombic-ovate or subcordate, on the branches becoming acute, gradually smaller and bract-like: monoecious, androgynous and also with unisexual clusters, floriferous and leafy-bracted throughout, the crowded clusters at the closely approximated nodes of the spike-like branches: calyx small, only the tips of the sepals free: anthers large: fruiting bracts suborbicular, about 5 ^{mm} broad, barely united above by the irregularly toothed narrow margins, the backs appendaged by short, thick, flat processes: radical superior.

This has heretofore been confused with the preceding, from which the three forms of flower clusters on the same plant, and the crowded bracteate spikes easily distinguish it. The axial branch of each plant is usually wholly staminate. Most of the specimens collected in the Rocky mountains north of New Mexico and ticketed *A. expansa* will be found to belong here. I make the type of the species my no. 8171, Laramie river, Wyoming, Sept. 1900.

ATRIPLEX ARGENTEA Nutt. Gen. **1**:198.—*A. volutans* Aven Nel-

[2] For distinctions in seed (fruit) characters see "Seeds of commercial saltbushes," Bull. 27, U. S. Dept. of Agric., Div. of Bot.

son, Bull. Torr. Bot. Club **25**:203.—In this species we have one of the most variable plants in respect to habit and size that has ever come under my observation. The original Nuttallian form is small and erect, but the large number of specimens at hand seem to furnish a complete series leading up to the other extreme represented by the large "tumble weed," often a meter in diameter, that was described as *A. volutans*. The distinctions as to the fruit characters are not sufficiently marked to maintain the latter as a species.[3] Its polymorphism is correlated with its wide range.

ATRIPLEX POWELLII Wats. Proc. Am. Acad. **9**:115.—Though this species is accredited to S. W. Colorado by Coulter's *Manual*, I am not sure that it rests upon any specimens except the type, which was grown under cultivation from seeds obtained from Arizona.

ATRIPLEX WOLFII Wats. Proc. Am. Acad. **9**:112.—This excellent species is still quite rare in herbaria, all the specimens seen by me being from Colorado. Allied to it but quite distinct, as will be seen, is the following:

Atriplex tenuissima, n. sp.—Annual, branched from near the base, the slender branches racemosely branched into filiform branchlets, 2–3^{dm} high, moderately white-scurfy throughout: leaves numerous, bract-like, oblong to lance-ovate or broader, 1–7 ^{mm} long: floriferous from near the base; the few-flowerd (1–3?) clusters axillary (pistillate plant the only one seen): fruiting bracts very small, mostly less than 2 ^{mm} long, triangular-ovate, completely united, forming a subpyramidal fruit irregularly and rather numerously tuberculate below the middle.

This proposed species is based upon a specimen in the Herbarium of the Missouri Botanical Garden, *M. E. Jones* 6525, Gunnison, Utah, Sept. 15, 1900, altitude about 1600 ^{m}. Distributed as *A. Wolfii*, to which it has some resemblance in habit, but the foliage and fruit are very distinct.

ATRIPLEX SACCARIA Wats. Proc. Am. Acad. **9**:112.—During several years of collecting in southern Wyoming, nothing answering to this description has yet been encountered, in this the supposed type locality. It seems barely possible that the species rests upon one of the numerous variations of the following:

[3] See Mr. G. N. Collin's valuable bulletin cited in the preceding footnote.

ATRIPLEX TRUNCATA (Torr.) Gray, Proc. Am. Acad. **8**:398.—If this species, like *A. argentea*, be confined within the limits of the original description, it becomes quite local and meagerly represented. Several forms, differing among themselves as to habit and size, and even to some extent as to fruit characters, seem best to leave united with it. A year ago the writer marked some of these forms for specific rank, and (unfortunately) went so far as to distribute two of them with herbarium names, "*ined.*" The numbers so distributed are 8141 and 8170. Including these forms its range now seems to be from W. Nebraska to Oregon.

ATRIPLEX SUCKLEYANA (Torr.) Rydb. Mem. N.Y. Bot. Gard. 1:134.—The original range, "upper Missouri and head-waters of the Yellowstone," may have added to it "near the North Platte and some of its tributaries."

Atriplex spatiosa, n. sp.—A large erect annual, freely and divergently branched, often 1^{m} high, greenish-gray, minutely scurfy throughout: leaves ovate, 2–5 ^{cm} long, coarsely and irregularly toothed, cuneate at base, rarely subhastate, nearly sessile, acute at apex with a minute cusp; the floral gradually reduced, becoming lanceolate and bract-like: monecious, androgynous at least above, the flowers in small axillary clusters and in ebracteate terminal spikes: calyx deeply 5-cleft: fruiting bracts small, rarely 5 ^{mm} long, ovate-triangular or orbicular, appressed, free above, with green border, hastately toothed near base or with several smaller teeth, the back crested with a semicircle (usually) of small slender green appendages.

This species came under my observation some three years ago, but the specimens secured happened to be found on loose banks and railroad grades, and it was suspected that it might be an introduction. It is proposed even now with some hestitation but with more confidence, since in the Herbarium of the Missouri Botanical Garden is found a specimen by *Dr. Vasey*, no. 487 (Powell's Colo. Expd. 1868), which undoubtedly is the same thing, though it was distributed as *Obione argentea*. Two others occur which are probably the same, namely, *Hayden*, Ft. Pierre, 1853; and *Hitchcock* 439, Kansas, 1895; these also as *A. argentea*. The relationship is nevertheless rather with *A. rosea* L.

The type number is 8140, Granger, Wyoming, Aug. 1900; *Elias Nelson* 737, Laramie, Wyoming, Sept. 1901, may be named as the co-type.

Atriplex carnosa, n. sp.—Annual, stout, branched, at length widely and diffusely so, sometimes nearly 1 m high: stems green, subglabrous: leaves thick and fleshy, oblong-lanceolate or broader, 3–7 cm long, on petioles less than half as long, mostly entire, the larger ones subhastate or with one or more large teeth near the base: fruiting spikes numerous, more or less panicled, at first dark green, becoming dark purple at maturity; the large fleshy clusters closely approximated, producing an almost continuous spike often 1 cm in diameter: fruiting bracts triangular-ovate, about 5 mm long and broad, usually one or more small teeth on the margins, smooth on the back or with one or two fleshy tubercles: radicle inferior or subascending.

This is a member of the *A. patula* group. *A. patula* does not occur in this region except as an introduction. Dr. Watson (Rev. N. A. Chenopodiaceae) states that the American form of *A. hastata* also differs somewhat from the European *A. hastata* L. It may of course at some time be separated. The other two varieties recognized by Watson are wholly distinct from the species now proposed, leaving only *A. lapathifolia* Rydb. Mem. N.Y. Bot. Gard. 7:133 with which to compare it. From this it seems to be distinct by its great fleshiness, its large spikes and lax habit, and hastately toothed leaves.

It occurs only in moist strongly alkali-impregnated soils, and seemingly extends from Nebraska across the middle Rocky mountains into Utah. The type is 8036, Laramie, Wyoming, 1900; wholly typical are 4465, Howell lakes, Wyoming, 1897; 1871, Laramie, Wyoming, 1895.

CHENOPODIUM.

Two years ago a very anomalous Chenopodium was discovered, growing in an alkali lake bed. The soil was moist, but the surface was covered with efflorescent salts. The plants were abundant and uniform in habit. The only known species that the plant suggested was *C. glaucum*. This led to an examination of *C. glaucum* and to further collections. After having seen many authentic specimens of both the introduced eastern form and the indigenous western form of *C. glaucum* there seems to be the best of reasons for designating this a new form as follows:

Chenopodium succosum, n. sp.—Stout, erect, 5–8 dm high, freely branched, the branches ascending or suberect, straw-

colored, the whole plant fleshy and exceedingly succulent (specimens curing slowly and saved with difficulty): leaves from broadly lanceolate to oblanceolate or even linear in outline, entire or irregularly toothed (often hastately toothed and resembling those of *Monolepis chenopodiodes*), 2–5^{cm} long, on petioles about half as long, green on both sides and not noticeably mealy: floriferous thoughout: flower clusters axillary, spicate, very numerous: calyx membranous; the sepals usually 3, suborbicular: pericarp thin, rather loosely covering the small dark brown seed.

It is at once distinguished from *C. glaucum* by its erect habit, size, succulence, greenness, crowded inflorescence, and small seeds. Type no. 8182*a*, Albany co., Wyoming, Sept. 5, 1900.

Chenopodium Watsoni, n. n.—*C. olidum* Wats. Proc. Am. Acad. **9**: 95, not *C. olidum* Curt. Fl. Lond. fasc. V. *t. 20.*

Chenopodium subglabrum (Wats.), n. sp.—*C. leptophyllum subglabrum* Wats. Proc. Am. Acad. **9**: 95.—The following characters seem to indicate that this rather rare plant is not very closely allied to *C. leptophyllum* Nutt. It is glabrous, usually bright green; loosely and slenderly branched, the branches very widely divaricate; the few-flowered clusters scattered on the branches. In this last respect especially it is as strongly marked as in its habit. The flowers are often borne singly and never more than two or three in a cluster. The fruit is large and depressed, and the calyx loose and open at maturity. Of several specimens examined in the herbarium of the Missouri Botanical Garden, no. 274, by Mr. Waugh, Stillwater, Oklahoma, shows the fully developed characters especially well. The range of the species seems to be from the Upper Platte in eastern Wyoming to Indian Territory.

In contrast with the preceding the var. *oblongifolium* of *C. leptophyllum* seems much less well marked. It is often difficult to say whether a given plant should bear the varietal or specific designation. Under this varietal name, however, a form has been found that by reason of its habit and other characters seems to deserve specific rank.

Chenopodium desiccatum, n. sp.—Annual, densely white mealy

throughout, freely branched, the branches paniculately branched, low and spreading, about 1^{dm} high (broader than high): leaves entire, from oblong to linear, mostly acute, some of them short petioled, $1-2^{cm}$ long: floriferous throughout; the small clusters in dense panicles which are naked towards the apex: calyx thickened with the dense mealiness, brittle, enclosing the fruit, the large (more than 1^{mm}) shining-black seed easily separable from the pericarp.

No. 5048, collected by *Elias Nelson*, Mill creek, Wyoming, Aug. 12, 1898 is made the type, while a collection by *J. H. Cowen*, Fort Collins, Colorado (wholly typical as represented in the Rocky Mountain Herbarium), July 29, 1896, may be designated the co-type.

Chenopodium cycloides, n. sp.—Annual, about 4^{dm} high, stoutish, divergently branched from near the base, nearly glabrous: leaves narrowly linear (the early ones wanting), $5-25^{mm}$ long, scattered on the branches or more crowded on slender branchlets, lightly scurfy on both sides: sepals 5, not scurfy, membranous, at maturity somewhat united and spreading, simulating a rotate wing about the large brown depressed or lenticular fruit: pericarp thin, close-fitting, transparent: seed more than 1^{mm} broad, embryo annular.

Of this seemingly remarkable distinct species I have seen but one collection, no. 435, by *A. S. Hitchcock*, Sand hills, Grant co., Kansas. It was distributed as *C. leptophyllum*, to which it is most nearly related, notwithstanding its very different appearance. The habit of the plant and its winged fruits at first sight suggest a Cycloloma rather than a Chenopodium. The type is the above number as it is found in the Herbarium of the Missouri Botanical Garden; the co-type, same number in the Rocky Mountain Herbarium.

DONDIA.

In the transfer of the different species from Suaeda to Dondia, there seems to have been some misunderstanding of the synonomy. Dr. Watson in his Revision (Proc. Am. Acad. **9**: 87–90) seems to have had this perfectly clear, and there the synonomy may be found in full up to that date. The following new combinations seem to be necessary:

Dondia Moquini (Torr.), n. comb.— *Chenopodina Moquini* Torr. Pacif. R. R. Rep. **7**: 18. 1856; *Suaeda Torreyana* Wats. Proc. Am.

Acad. 9:88, 1874; *Dondia multiflora* Heller, Cat. N. A. Pl. 3. 1898.

Dondia multiflora (Torr.), n. comb.—*Suaeda fruticosa multiflora* Torr. Pacif. R. R. Rept. 4:130. 1857; *S. suffrutescens* Wats. Proc. Am. Acad. 9:88. 1874; *Dondia suffrutescens* Heller, Cat. N. A. Pl. 3. 1898.

Dondia erecta (Wats.), n. sp.—*Suaeda depressa erecta* Wats. Proc. Am. Acad. 9:90. 1874; *Dondia depressa erecta* Heller, Cat. N. A. Pl. 3. 1898.

This is given specific rank, not because a depressed erect plant is an anomaly, but because by reason of its constant well marked habit it is quite distinct. Not only is it erect, but its narrow leaves and strict branches give it an aspect quite its own.

MISCELLANEOUS SPECIES.

Recently a specimen of *Abronia fragrans* Nutt. was received from T. D. A. Cockerell, of New Mexico. It seemed so different from the Wyoming form of that species that it led to an inquiry as to the typical *A. fragrans*. All the literature indicates a viscid pubescent plant, and that is just what we find in specimens secured to the southward and eastward of Wyoming. The Wyoming form, which seems to extend northward and westward, differs so essentially, it seems to me, that it may well bear a varietal name.

ABRONIA FRAGRANS **glaucescens,** n. var.—Growing in clumps, freely branched, suberect, 15–25 ^{dm} high: stems glabrous or nearly so below, upwardly becoming puberulent and subviscid: leaves wholly glabrous, light green above, lighter and more or less glaucous below (often silvery-glaucous): the white flowers crowded in the involucres and forming spherical clusters 5 ^{cm} or more in diameter (locally known as "snowballs"): fruit terminating in a conical beak one-third as long as the narrowly winged obconical body.

Abronia cheradophila, n. n.—*Abronia arenaria* Rydb. Mem. N. Y. Bot. Gard. 1:137; not *A. arenaria* Menzies, ex. Hook. Exot. Fl. *t. 193*.

Allionia glandulifera, n. sp.—Perennial from woody rootstocks: stems one or more from the crowns, somewhat dichotomously

branched, finely striate, silvery-glaucous below, greener upward and becoming glandular-pubescent, 3–5 dm high: leaves linear-lanceolate, mostly with one or more pairs of lateral nerves, obscurely undulate-toothed, glabrous or the uppermost viscid-pubescent, green and nearly normal in texture, 7–12 cm long, 5–10 mm broad: inflorescence a large freely branched cyme, nearly naked, densely viscid or glandular-pubescent throughout, even on the small bracts: involucres mostly three-flowered, salverform in anthesis, 1 cm or less in diameter, the bracts elliptic-ovate, subacute, distinct nearly to the base: perianth white or pinkish, broadly funnelform, 7–10 mm long, hirtellous without and within; its limb deeply four-lobed, each lobe bifid, giving eight subequal obtuse elliptic segments: stamens three, well exserted as also the style: fruits narrowly obovate, about 5 mm long, inconspicuously ribbed, somewhat tumidly rugose, moderately pubescent.

This is the Rocky mountain form of what has passed as *A. linearis* Pursh, but from that it is readily distinguished by its broader leaves of normal texture, its viscid-pubescent paniculate cyme, and the bifid lobes of the perianth.

ENOMEGRA.[4]—Coarse perennial herbs with thick milky (white) sap and alternate pinnate or bipinnate leaves; green or sometimes glaucescent but not blotched with white; densely hispid-spinescent on stem and capsules and more sparsely so on the toothed lobes of the leaves and on their veins; also a short puberulence which on the stem and especially on the capsules tends to become hispid. Flowers subsessile, in close clusters on the ends of the leafy simple stems. Sepals 3, hispid near the cornuate, subcucullate apex, conspicuously reticulate veiny and inequilateral by the wing-like membranous margin on one side. Petals 4–6, white, suborbicular or reniform. Stamens numerous, filament and anther both narrow, sub-equal. Stigma dilated, four-lobed. Capsule cylindric-ellipsoid, four-valved. Seeds numerous, flattened, scarcely pitted. (Anagram of *Argemone*.)

This genus must rest mainly upon the color of the sap (no one seems to have made the observation that it is white), the character of the pubescence, the simple stems, and the crowded inflorescence. The glaucescent blotching

[4] This new genus unintentionally reached publication first in the writer's *Key to Rocky mountain flora* (1902), p. 27, but it seems best to give it this fuller additional publication.

with white in Argemone is noticeably absent in Enomegra. *Argemone intermedia* and *Enomegra bipinnatifida* are often associated in the field but are never confused. The veriest tyro distinguishes them almost as far as he can see them, as I have repeatedly proven. Even children before breaking them down say "yellow" (sap), "white," "yellow," "white," etc. Possibly the genus is monotypic but I rather suspect not. In either case some of the characters given above are specific rather than generic. Collectors too often make inadequate notes, and even in plants of this family the color of the sap is not mentioned. I have not collected personally the second of the species that follow.

Enomegra bipinnatifida, n. comb.—*Argemone bipinnatifida* Greene, Pitt. **3**: 346.

ENOMEGRA HISPIDA, Aven Nelson, *Key Rocky Mt. Fl.* 27.—*Argemone hispida* Gray, Pl. Fendl. 5.

Draba uber, n. sp.—Stems several to many from a short branched caudex, moderately stout, 1–2 dm high (including the long fruiting racemes), lightly pubescent with mostly simple hairs: basal leaves densely rosulate on the crowns, oblanceolate, 1–2 cm long, tapering into a short petiole or subsessile, moderately stellate-pubescent as are also the stem leaves; stem leaves few, oblong, sessile but neither auriculate nor clasping: inflorescence crowded in fruit as well as in flower; flowers yellow, small: sepals subglabrous: petals spatulate, 4–6 mm long: fruiting from near the base up, the dense raceme leafless and ebracteate above the middle: pedicels stoutish, ascending, about 5 mm long: pods lanceolate, 10–12 mm long, puberulent with mostly simple hairs, 24–36-seeded, usually strongly twisted; style evident (1 mm), stoutish, glabrous.

In habit this species simulates *D. streptocarpa* Gray, but in some of the floral and fruit characters it is most nearly allied to *D. surculifera* Aven Nelson. From the latter it differs in the smaller leaves, long crowded fruiting raceme, narrower petals, more numerous seeds, and the denser and more uniform pubescence. *D. surculifera* occupies shaded slopes, under cliffs and trees in subalpine stations, while *D. uber* is found on open alpine slopes. Type no. 7875, Telephone mines, August 1, 1900.

Lesquerella macrocarpa, n. sp.—Moderately stellate-pubescent throughout; freely branched from crown of a slender taproot; the branches decumbent-spreading with assurgent tips, 7–15 cm long: crown leaves from orbicular to obovate, 7–20 mm long,

mostly short petioled; stem leaves from broadly to narrowly oblong or oblanceolate, 15–30 mm long including the short tapering petiole: raceme crowded even in fruit, naked above: petals obovate, emarginate, two of them with slightly narrowed and claw-like base, 5–7 mm long: pod nearly globose, 5–8 mm in diameter, two or three ovules in each cell; style 2–3 mm long: pedicels recurved, 5–10 mm long.

This excellent species has the appearance of a Physaria, but of course is at once separated by the fruit. It was secured on naked clay flats and ridges on the Red desert, near the Bush ranch, Sweetwater co. Wyoming, June 10, 1900. The type number is 7081. It was again collected not far from the type locality in June 1901, by *Merrill* and *Wilcox*, no. 568.

Opulaster Ramaleyi, n. sp.—Shrubby, 1–2 m high; the stems and older branches brown with fibrous-shreddy bark; young branchlets green, glabrous and somewhat angled: leaves numerous and large, broadly ovate or subcordate in outline, some of them slightly incisely 3-lobed, the margin more or less doubly crenately dentate, 2–7 cm long and almost as broad, glabrous on both sides except occasionally some ciliolations on the veins below: pubescence on pedicels soft and rather long, somewhat tufted and substellate; on hypanthium and calyx short, hoary-tomentose: sepals ovate, acute, soon reflexed in blossom but erect in fruit, about 3 mm long: petals orbicular, slightly exceeding the sepals: anthers dark purple: ovaries four, loosely united to the middle, densely pubescent; carpels elliptic, inflated, more than twice as long as the sepals, about 7 mm long, moderately divergent, nearly distinct, pubescent, somewhat laterally compressed at apex and terminated by the short style, usually three maturing (sometimes only two): seeds single in the cells, obovoid, shining, about 2 mm long.

This is *O. opulifolius* probably, in so far as Rocky mountain specimens have been so named. It is not the *O. opulifolius* (L.) Kuntze of the eastern United States. The characters as given show that, and it is at once evident to the eye when both species are seen together. The type specimens are nos. 108, 793, and 874 by *Francis Ramaley*, all from the same locality, near Boulder, Colorado, 1900 and 1901. The earlier number is in blossom, the two later in fruit. No. 2406 by *G. E. Osterhout*, 1901, is the same and from the same locality.

Anogra Nuttallii, n. comb.—*Oenothera albicaulis* Nutt. Fras. Cat., name only; T. & G. Fl. N. A. 1: 495; not Pursh, Fl. Am. Sept. 733; *O. Nuttallii* Sweet, Hort. Brit. Ed. 2: 199.—Perennial from woody horizontal rootstocks with short vertical caudices or crowns: stems one to several from the crown, erect, 5–10^{dm} high, freely branched above, the somewhat shreddy bark white and glistening; branchlets slender, widely divaricate: leaves very numerous, somewhat fascicled at the axis, softly and minutely puberulent on the lower surface, broadly linear, acute at apex, tapering gradually to the nearly sessile base, margin entire or merely denticulate; the primary ones of the fascicles 4–10^{cm} long, 5–8^{mm} broad; the secondary ones similar but quite small: flowers in the crowded terminal axils of the branches, somewhat drooping in bud: calyx glandular-puberulent on the tube; calyx-lobes narrowly lanceolate, 2–3^{cm} long, about as long as the tube, scarcely puberulent, the tips free: petals white, broadly obovate, entire or denticulate at the broad apex, nearly as long as the reflexed calyx-lobes: anthers linear, 15^{mm} long, as long as the filament: stigmas exserted, linear, about 10^{mm} long: mature capsule cylindrical, about 3^{cm} long, pale, minutely puberulent except on the rather broad whitish sutures, not contorted: seeds narrowly ovate, light green, copiously speckled with purple, indistinctly striate under a lens, about 2^{mm} long.

I have long intended to give a name to this perfectly valid species. In fact I have distributed some specimens under the herbarium name *Anogra arenaria.* A more careful study of the synonomy convinces me now that the above name is tenable. *Oenothera albicaulis* Nutt. never was a synonym of *O. pallida* Lindl. Bot. Reg. 14: *pl. 1142.* It was evidently the purpose of Sweet to distinguish this species of Nuttall from Pursh's species of the same name, as it was also of Spach in his *Baumannia Nuttalliana* (Hist. Veg. 4: 352) and *Anogra Nuttalliana* (Nouv. Ann. Mus. Par. 4: 339).

This species is very common on sandy plains and banks from Nebraska to Utah. It is at once distinguishable from *Anogra pallida* by the pubescent leaves, inflorescence, and capsules; the larger flowers (resembling those of *A. albicaulis* Pursh rather than those of *A. pallida*), and the larger straight capsules and characteristic seeds.

Lavauxia Howardi (Jones), n. comb.—*Oenothera Howardi* Jones, Zoe 3: 301.—For some reason this species has been completely ignored by recent writers on the allies of *Oenothera*, as

has also *Oenothera Johnsoni* Parry, Am. Naturalist **9**: 270. Jones suggests the possibility that the species he describes is *O. Johnsoni*, but at the same time points out characters that unmistakably distinguish the two. While the description of *O. Johnsoni* is very meager, yet in so essential a matter as the character of the capsule it is very explicit. Certainly no observer, least of all Parry, would have compared a large perennial such as *Lavauxia Howardi* with the small annual *Lavauxia priminervis* (Gray) Small, which has a capsule similar to that attributed to *O. Johnsoni*. The species to which *Lavauxia Howardi* is closely allied is *L. brachycarpa* (Gray) Britton Mem. Torr. Club **5**: 235; *Oenothera brachycarpa* Gray, Pl. Wright **1**: 70, and Coulter, Contrib. U. S. Nat. Herb. **2**: 116; but here again the character of the capsule serves to distinguish these two. In the latter it is smooth and acute, with narrow wings; while in the former it is larger, oblong-obtuse, broadly winged, and cinereous pubescent. The leaves also are all oblanceolate, tapering into the petiole, from entire to coarsely and irregularly toothed, therefore the lamina continuous and not distinguished into lateral and terminal lobes.

The species occurs on arid denudated hills from northern Colorado through Utah to Nevada.

COLORADO AND WYOMING THORNS.

Crataegus Wheeleri, n. sp.— Probably a small shrub, the branches slender and virgate: leaves narrowly oblong to elliptic, 3–5^{cm} long, 1–2^{cm} broad, from acute to obtusely rounded at apex, cuneately tapering at base to a slender petiole one-fourth to one-half as long as the blade, the shallow crenate serratures wanting on the cuneate base, light green and glabrous below, brighter green but obscurely and sparsely appressed strigulose above, firmer in texture and somewhat glossy above at maturity: spines slender, flexible, glossy black, 2–3^{cm} long: flowers small, 12–14^{mm} broad, on slender glabrous pedicels, in close few-flowered corymbs: calyx-tube obconic, glabrous; calyx-lobes small, triangular, at length reflexed: petals suborbicular, about 4^{mm} in diameter: stamens 20; anthers yellowish-white: pistils 5: fruit small, sub-globose, 6–8^{mm} in diameter, purplish-black (in dried specimens), in few-fruited suberect clusters; flesh seem-

ingly very thin and dry: nutlets 5, nearly smooth, about 5^{mm} long.

This species is not so well represented before me as I wish it were, but it is so evidently distinct from the known Rocky mountain species that I have no hesitancy in pronouncing it new. Among the western species it is most nearly allied to *C. rivularis* Nutt. The size of the tree or shrub is not known to me, but from the herbarium specimens I suspect that it is quite small. The type was collected by *H. N. Wheeler* at Sapinero, Colorado, 1898, no. 532; co-type, *C. S. Crandall's* collection in the Black cañon of the Gunnison, Colorado, August 22, 1896.

Cartaegus cerronis, n. sp.—Tree-like in form, 2–5^{m} high, rather widely branched; trunk short and stout, with rough bark; young twigs brown, passing into the gray of the older ones; lenticels small, nearly white: leaves broadly elliptic-ovate, 3–5^{cm} long, 2–3^{cm} broad, coarsely and serrately few-toothed, the teeth with finer gland-tipped acute serrations, acute or acuminate at apex, the abruptly cuneate base entire or remotely serrulate, light green and perfectly glabrous below, sparsely ciliate pubescent above, especially on the veins; petiole slender, without glands, chaneled above, 5–20^{mm} long: thorns numerous, short (2–3^{cm}), stout and thick for the length, straight, rarely a little deflexed, very dark morocco-red, with small light-covered lenticels: the paniculate corymb 5–10–flowered, congested in blossom but more open in fruit: calyx tube only 2–3^{mm} long, shorter than its lobes; lobes ovate, with a broad gland-margined acumination: petals suborbicular, with shallow crenations, noticeably reticulate veined, 6–8^{mm} broad: stamens few (1–8, mostly 5–8); anthers large, purple: pistils 5: mature fruit not at hand; nutlets 5.

This excellent species seems to be an inhabitant of Colorado and Wyoming. I take as the type *Baker's* no. 46, Cerro summit, Colorado (altitude about 2500^{m}), flowers June 7, fruit July 12, 1901; excellent flowering specimens, 660 *Ramaley*, near Boulder, Colorado, May 20, 1901. The following numbers from Wyoming, by the writer, are probably the same, though only fruiting specimens are at hand: 2491, Pass creek, 1896; 606, Casper, 1894; also 5060, by *E. Nelson*, Seminole mts., 1898. It has probably at times been distributed as *C. rivularis* Nutt., but it has rather the appearance of *C. Douglasii* Lindl.

Crataegus sheridana, n. sp.—Becoming a small tree 3–5^{m} high; the young twigs gloss-brown or red-brown, becoming

grayish on older branches; lenticels rather few and large; spines slender, noticeably curved and deflexed, 4–5^{cm} long, dark brown, the glazed surface marked by the few whitish lenticels: leaves oval to almost orbicular, coarsely and incisely toothed with rather blunt gland-tipped serratures, the rounded or abruptly cuneately-narrowed base merely serrate and scarcely decurrent upon the slender petiole; pubescence various, sparse and softly strigose on lower surface of leaves (mostly on the veins), minute and appressed on the upper, ciliate on the petioles, the youngest twigs, the pedicels, the calices, and fruits: corymb 5–11 flowered: calyx-lobes ovate-lanceolate, with several glands on the margins, 4–5^{mm} long: stamens (seemingly) 8–10: pistils 3 or 4: nutlets 3–5, often slightly crested-bisulcate dorsally, about 5^{mm} long: fruit nearly spherical, 8–9^{mm} in diameter, scarlet-red.

The Crataegus here described has passed for *C. macrantha* Lodd. While it may be most nearly allied to that it is doubtful if anything referable to that species occurs in the Rocky mountains. Another close ally of it is found in *C. Piperi* Britt., from which it differs in pubescence, the absence of glands on the petioles, in the straight styles, the shorter filaments, and the smaller differently colored fruits.

The type is no. 8673, Sheridan, Wyoming, July 24, 1901; fully ripe fruits from same locality October, 1902. Sundance, Wyoming, July 2, 1896, no. 2104, seems to be the same.

UNIVERSITY OF WYOMING,
Laramie.

BRIEFER ARTICLES

A NEW HEPATIC FROM THE EASTERN UNITED STATES.

(WITH PLATE XII)

ALTHOUGH the species of Diplophylleia described below is not uncommon along the Atlantic coast, and has long been known to hepaticologists, it has been confused with other members of the genus. As the synonymy shows, Sullivant referred the plant to *Jungermannia obtusifolia* Hook., now known as *Diplophylleia obtusifolia* Trevis. This distinct species is widely distributed in Europe and has recently been reported by Stephani from Japan.[1] The only American station, however, which can be quoted with any degree of certainty is Hector, British Columbia, where it was collected in 1889 by Macoun and distributed in *Canadian Hepaticae*, no. 100. Austin threw doubts upon Sullivant's determination of the eastern plant, but instead of recognizing in it a distinct species referred it as a forma *minor* to his *Scapania albicans*, var. *taxifolia*. Nearly every writer on the Hepaticae now regards this so-called variety as a species distinct from *Diplophylleia albicans* (L.) Trevis., and it appears in recent literature as *D. taxifolia* (Wahl.) Trevis. With regard to the exact status of Austin's var. *taxifolia minor*, no views have recently been expressed except those of Pearson,[2] who apparently accepts the old determination of Sullivant.

Diplophylleia apiculata, sp. nov. — *Jungermannia obtusifolia* Sull., Gray's Manual, Ed. 1, 694. 1848 (not Hooker). *Scapania albicans*, var. *taxifolia minor* Aust. Hep. Bor.-Amer. 23. 1873.— Yellowish-green, more or less tinged with brown or red, growing in depressed mats: axes 0.17^{mm} in diameter, sparingly pinnate, both primary and secondary prostrate at the base and ascending toward the apex, with abundant pale rhizoids in the prostrate portions: leaves imbricated, deeply and unequally complicate-bilobed; antical lobe erect-spreading, ovate, 0.4^{mm} long, 0.2^{mm} wide, slightly narrowed at the base and attached by an almost transverse line of insertion, not decurrent, apex varying from rounded to subacute, mostly apiculate, margin entire or indistinctly and irregularly denticulate; keel slightly concave; postical

[1] Bull. Herb. Boissier **5**: 78. 1897. [2] Hepaticae of the British Isles, 242. 1900.

lobe falcate, linguiform, 0.75^{mm} long, 0.3^{mm} wide, scarcely narrowed at the almost transverse base, apex obtuse to subacute and usually apiculate, the apiculum consisting of one or two cells, margin subentire or sparingly and irregularly denticulate, especially toward the base, occasionally with one or more coarser teeth near the apex, postical margin usually forming a distinct but wide angle with the keel; cells of lobes isodiametric in apical region and along free margin, 12 μ in diameter at the apex, 18 × 12 μ in the middle, and 32 × 12 μ at the base and along keel, cell-walls somewhat thickened, the thickening more or less uniform but with evident trigones in the median and basal portions of the lobes, cuticle varying from densely and finely verruculose to nearly smooth: inflorescence autoicous: ♀ inflorescence usually on a short branch, more rarely on an elongated branch, sometimes innovating on one or on both sides, commonly without innovation; leaves increasing rapidly in size toward perianth; bracts mostly in two or three pairs, similar to the leaves, their lobes obtuse to rounded but usually apiculate at the apex, antical lobe 0.85^{mm} long, 0.35^{mm} wide, postical lobe 1.2^{mm} long, 0.45^{mm} wide; perianth about one-third exserted, obovoid, 1.4^{mm} long, 0.7^{mm} wide, narrowed toward the base, somewhat constricted at the mouth, slightly compressed and with four to six grooves in the upper part, separated by rounded keels, mouth irregularly lacerate with setulose divisions, the ultimate setae sharp, one to three cells long: ♂ inflorescence borne on a leading branch, more rarely on a short branch, often proliferating at the apex and again floriferous; bracts in two or three pairs, similar to the leaves but with a strongly convex keel, antical lobe broad, inflated at the base; antheridia borne singly; paraphyses wanting: capsule oval, reddish-brown, borne on a slender stalk; spores 13μ in diameter, yellowish, minutely verruculose: gemmae borne in irregular masses at the apices of the upper leaves of a branch, composed of one or two angular cells.

On shaded banks. RHODE ISLAND: Providence and Exeter (*Collins*). CONNECTICUT: Killingworth (*Hall*); Woodbridge and Hamden (*Eaton*); Orange (*Evans*). PENNSYLVANIA: Philadelphia (*James*). DISTRICT OF COLUMBIA (*Holzinger*). VIRGINIA: Comer creek (*Mrs. Britton* and *Miss Vail*). GEORGIA: Tallulah falls (*Underwood*). The specimens from Orange, Conn., in the herbarium of the writer, may be designated as the type.

EXSIC.: *Musc. Alleg.* 230 (as *Jungermannia obtusifolia*); *Hep. Bor.-Amer.* 23 (as *Scapania albicans*, var. *taxifolia minor*).

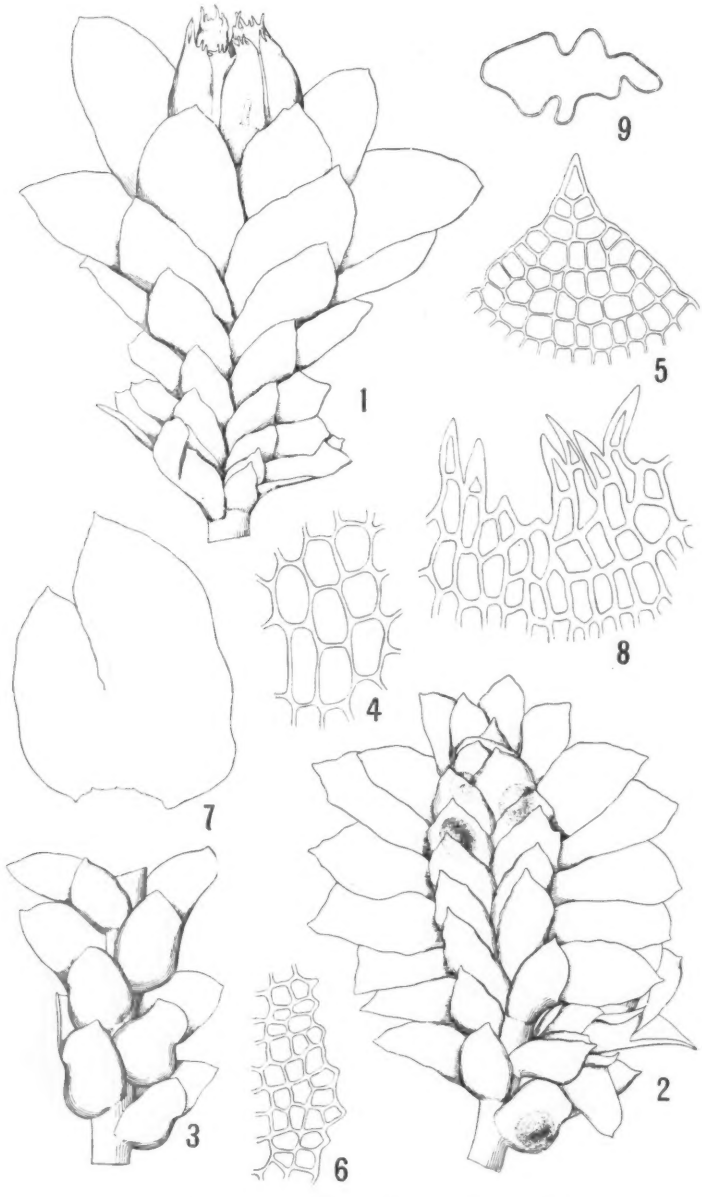
Whether the inflorescence of *D. apiculata* is invariably autoicous or whether it may sometimes be dioicous is difficult to determine, since it

is not always possible to demonstrate the connection between the male and female axes. This is especially true of plants with fully developed perianths, because the short female branches very early root at the base, lose their connection with the parent axes and continue their development independently. In plants with young perianths, however, and more particularly in those with unfertilized archegonia, the connection between male and female branches is usually clear and apparently indicates the normal condition of the species. The fact that a male axis sometimes proliferates at the apex and bears several successive male inflorescences without branching might seem to indicate that the species was on the way to becoming dioicous. Such a male branch indeed becomes eventually a distinct unisexual individual from the dying away of its older portions. Nevertheless, the occurrence of male individuals in a monoicous species is by no means unusual and is apparently brought about in some cases by unfavorable conditions.

The new species is related to *D. taxifolia* and also to *D. obtusifolia* and is in some respects intermediate between them. It is a smaller plant than *D. taxifolia* and differs from it also in its apiculate leaves and in its inflorescence, which is autoicous instead of dioicous. *D. taxifolia*,[3] moreover, occurs usually on shaded rocks, while the new species prefers earthy banks. *D. apiculata* agrees with *D. obtusifolia* in its size and also in its place of growth, but differs from it in its apiculate leaves and bracts and in being autoicous instead of paroicous. *D. obtusifolia*, to be sure, occasionally produces branches which are purely male, but these occur on the same individuals or at any rate in the same tufts as bisexual branches, and the latter are undoubtedly the more typical. Another close relative of *D. apiculata* is *Diplophyllum gymnostomophilum* Kaalaas[3] of Norway and Sweden. This species is dioicous, the male and female plants growing in distinct tufts. The Italian *Diplophylleia scapanioides* Massal.,[4] a near ally of the Scandinavian species, is also dioicous. — ALEXANDER W. EVANS, *Yale University*.

[3] *Scapania gymnostomophila* Kaalaas, Bot. Notiser 1896 : 21. *Martinellia gymnostomophila* Arnell & Jensen, Bihang till K. Sv. Vet.-Akad. Handl. 21^{10} : 28. *pl.* — *f. B.* 1896. *Diplophyllum gymnostomophilum* Kaalaas, Vidensk. Skrift. I. 1898^{9} : 4–9. *f. 1–4.*

[4] *Jungermannia seapanioides* Massal. Acta Soc. Ven.–Trent. **6** : [64]. *pl. 3.* 1879. *Diplophylleia scapanioides* Massal. Ann. dell' Ist. Bot. di Roma 2^{2} : [18]. 1886. See also C. Müller (Freiburg), Bot. Centralblatt **82** : 411. 1900.



DIPLOPHYLLEIA APICULATA Evans

EXPLANATION OF PLATE XII.

FIG. 1. Branch with perianth, antical view. × 36.
FIG. 2. Branch with ♂ inflorescence, antical view. × 48.
FIG. 3. Branch with old perigonial bracts. × 48.
FIG. 4. Cells from middle of postical lobe. × 420.
FIG. 5. Cells from apex of same. × 300.
FIG. 6. Cells from margin of same near base. × 300.
FIG. 7. Perichaetial bract. × 48.
FIG. 8. Teeth from mouth of perianth. × 300.
FIG. 9. Cross-section of perianth in upper third. × 48.
The figures are all drawn from the type-specimens.

CURRENT LITERATURE.

MINOR NOTICES.

C. H. ROBISON, instructor in biology in the high school of Oak Park, Illinois, has published a pamphlet entitled "Outlines for field studies of common plants" that deserves attention. It is the result of a large and successful experience in such work with pupils of high school age. The price is 25 cents, and copies can be obtained by addressing the author.—J. M. C.

W. L. JEPSON[1] has published a school flora for the Pacific coast, a companion book to Nelson's *Key to Rocky mountain flora* and Coulter's *Analytical key to flowering plants* for the northeastern states. Of all these areas perhaps Professor Jepson's was the most difficult to treat in the selective way, since it comprises three very dissimilar botanical regions. However, no one is better fitted to have made this selection than the author, and the descriptions show the great personal familiarity of the field student.—J. M. C.

THE SEVENTH PART of the *Catalogue of Canadian plants* has just appeared. The sixth part was published in 1892, and contained a list of the Canadian mosses. The present part contains the liverworts and lichens. The liverworts number 196 species, and the lichens 614. An extensive "Addendum to Part VI" (138 pp.) is also published, bringing up to date "our knowledge of American mosses north of the United States." Professor Macoun is to be congratulated upon the persistent way in which this very valuable catalogue is being pushed to its completion.—J. M. C.

THE VOLUME OF the *Proceedings of the Indiana Academy of Science* for 1901, just issued, contains the following botanical papers: Flora of Eagle lake and vicinity, by H. W. CLARK; The vegetation of abandoned rock quarries, by MEL T. COOK; Contributions to the flora of Indiana, by STANLEY COULTER; Effect of the composition of the soil upon the minute structure of plants, by H. B. DORNER; Correlation of forestry and the sciences, by W. H. FREEMAN; A study of the histology of the wood of certain species of pines, by KATHERINE E. GOLDEN; The germinative power of the conidia of *Aspergillus Oryzae*, by MARY F. HILLER; A collection of myxomycetes, by F. MUTCHLER; Spore resistance of loose smut of wheat to formalin and hot water, and Some additions to the flora of Indiana, by WILLIAM STUART; Forestry in Indiana (Presidential address), by M. B.

[1] JEPSON, WILLIS LINN, A school flora for the Pacific coast. vi + 96. New York: D. Appleton and Company. 1902.

THOMAS; Notes on apple rusts, and Notes on the genus Stemonitis, by H. H. WHETZEL; The plant ecology of Winona lake, by LUCY YOUSE. The secretary of the Academy is John S. Wright, Indianapolis, Ind.—J. M. C.

NOTES FOR STUDENTS.

STUDENTS OF STEM ANATOMY will be interested in a recent paper of Solms-Laubach[2] upon the branching of *Isoetes lacustris*. The occurrence of a large number of branching specimens of unusual luxuriance and size, in a lake visited by the author in 1897, led him to a detailed study of the stem and a review of the literature upon the subject.—FLORENCE M. LYON.

TOBLER[3] finds that the thallus of one of the Rhodomelaceae, namely *Dasya elegans*, breaks down into single cells and cell-groups under certain conditions, and that these cells retain their vitality and finally develop new thalli; after the manner of the process which occurs so often in the Conjugatae and Confervoideae. The exact conditions under which this breaking down occurs were not worked out, but the author is sure the active stimulus is not one of increase in concentration of the external solution.

Observation that the ultimate branches of *Bryopsis plumosa* fall off and exhibit a marked power of growth somewhat similar to that just described, and that they sometimes form long siphonaceous tubes much resembling those of Vaucheria, has been made by Wright[4] and recorded in a recent note. --B. E. LIVINGSTON.

TWO FUNGUS DISEASES of the white cedar (*Cupressus thyoides*) are described in a recent paper by Harshberger.[5] These are caused by *Gymnosporangium biseptatum* Ellis, and *G. Ellisii* (Berk.) Farlow, both of which grow in the wood of the cedar. The author discusses the normal structure of the cedar wood, paying special attention to the number of tracheids in the various annual rings, and the conditions which influence their development. The influence of the growth of the fungus mycelia in the stems is evidenced by the formation of swellings, which show a large increase in the number of tracheids and increased activity of the phellogen. In the swellings caused by *G. biseptatum*, many of the tracheids appear to be plugged by a substance which the author calls "fungus gamboge." A detailed description of the structure of the swellings, the mycelia, and a consideration of the relation of the host cells and the hyphae follow.—H. VON SCHRENK.

[2] SOLMS-LAUBACH, H. GRAF ZU, *Isoetes lacustris*, seine Verzweigung und sein Vorkommen in den Seen des Schwarzwaldes und der Vogesen. Bot. Zeit. **60**: 179–206. *pl.* 7. 1902.

[3] TOBLER, F., Zerfall und Reproductionsvermögen des Thallus einer Rhodomelacee. Ber. Deutsch. Bot. Gesell. **20**: 357–365. 1902.

[4] WRIGHT, E. P., Note on *Bryopsis plumosa*. Notes from Bot. School Trin. Coll. Dublin. **1**: 174–175. 1902.

[5] HARSHBERGER, JOHN W., Two fungus diseases of the white cedar. Proc. Acad. Nat. Sci. Philadelphia, 1902: 461.

A NEW SUGGESTION as to the nature and origin of protoplasm has been made by Herrera.[6] By triturating the acetate, carbonate, or chlorid of calcium with glacial phosphoric acid, and then treating the resulting substance with salt solutions, the author obtains a mass which behaves under the microscope very much as does protoplasm. It shows amoeboid motion, a vacuolar or granular structure, plasmolyzes in certain cases when treated with plasmolyzing solutions, can be stained with methyl green, has its movements accelerated by sodium chlorid, etc. Herrera ventures the tentative hypothesis that "natural protoplasm is an inorganic metaphosphate impregnated by various substances absorbed or secreted under special osmotic and electric conditions." From the standpoint of such an hypothesis the theoretical explanation of the first appearance of the living substance upon the earth might not be such a difficult problem as it has heretofore seemed.—B. E. LIVINGSTON.

IN A PRELIMINARY NOTE Kuckuck[7] describes the phenomenon of zoospore production in *Valonia ovalis*. Parts of the protoplasm contained in the one-celled, bulbous thallus divide into zoospores, which escape through several openings produced by an apparent local absorption of the cell wall. After the escape of the zoospores these openings close and the remaining protoplasm occupies the entire cell, which resumes its normal vegetative appearance and continues the normal life processes. This is a case where during a very active period the protoplasm exists perfectly free from the conditions of turgor, so important at all times in most plant organisms; during the escape of the zoospores the large vacuole of the cell is in direct connection with the external solution through the several openings. Another curious fact is that the reproductive portion of the plasma is not separated by a wall from the vegetative part. In this respect Valonia differs from the other forms of the Siphoneae which have been studied; in them either the whole cell takes part in zoospore production and thus ends its career (Botrydium), or the portion so taking part is cut off from the rest by a wall formed previous to the actual division into zoospores (Codium, Bryopsis, Vaucheria).—B. E. LIVINGSTON.

IN A CONTINUATION of his studies on the lichens, Baur[8] makes valuable additions to our knowledge of the development of the apothecia in a number of genera, and a résumé is given of the evidence for the sexuality of the lichens. The ascogons and trichogynes of Parmelia and Pertusaria are specially described and figured. Particularly interesting are Baur's observa-

[6] HERRERA, A. L., Le protoplasma de métaphosphate de chaux. Mem. Rev. Soc. Sci. "Antonio Alzate," Mexico **17**:201–213. 1902.

[7] KUCKUCK, P., Zur Fortpflanzung von *Valonia* Gin. Ber. Deutsch. Bot. Gesell. **20**:355–357. 1902.

[8] BAUR, E., Die Anlage und Entwickelung einiger Flechtenapothecien. Flora. **88**:319–332. *pls. 14–15*. 1901.

tions on *Pertusaria communis*. Krabbe who studied the same lichen states that he found no trace of sexual organs or of a differentiation of ascogons and paraphyses. Baur's sections show the characteristic thick, coiled ascogons and trichogynes and the later developed ascogenous hyphae most sharply differentiated from the surrounding vegetative tissue from which arise the paraphyses. Of special interest in this lichen is the capacity for indefinite development shown by the ascogenous hyphae. Growing and branching richly at their tips and dying off at their basal ends as they advance, they spread through the thallus and form apothecia at various points, even 2 mm distant from the original trichogyne and ascogon from which they arose. Such extended independent growth of the ascogenous hyphae forms a good parallel to what Watnio has already claimed for Cladonia. Baur also describes the development of the pyrenolichen *Pyrenula nitida*, and finds here also the characteristic differentiation of ascogon and trichogyne. The recent work of Baur and others has made the morphology of the ascocarp for the entire family of the lichens better known than it is in any other similar series of Discomycetes.—R. A. HARPER.

SINCE THE APPEARANCE of Czapek's answer to Wachtel's paper on the method of bent tubes to demonstrate the sensitiveness of root-tips to the gravity stimulus, we have had a desire for some entirely different method by which this long-discussed question could be attacked anew. Czapek's position seemed to be established, but the lack of confirmatory evidence from other sources has been still noticeable. In a recent paper by Francis Darwin[9] a new method of approach is described. It is a modification of that used by him[10] in showing that the cotyledon of Setaria, Sorghum, etc., is the perceptive region in geotropic curvature of the hypocotyl. Since the root tip is slimy and the whole organ mechanically weak, it is impossible to fix the tip in a horizontal tube and have it support the weight of the rest of the seedling. The new method obviates this difficulty by affixing the cotyledons to the end of a long lever free to move in both a vertical and horizontal plane. The lever is of course counterbalaned, and thus the cotyledons (of beans in this case) are able to move freely in any direction in a spherical plane, whose radius of curvature is the length of the supporting lever-arm. When the cotyledons are so supported the root-tip is placed in a horizontal tube (of straw, dandelion scape, etc.), and complete turns are executed by the curving root. The method is difficult of operation, and a large number of experiments failed because the root-tip slipped from the tubes. But the author believes he has demonstrated in this way that as long as the tip is horizontal the response of the growing region produces a continuous curve resulting in

[9] DARWIN, F., On a method of investigating the gravitational sensitiveness of root-tip. Jour. Linn. Soc. **35**:266–274. *figs. 1–10.* 1902.

[10] DARWIN, F., On geotropism and the localization of the sensitive region. Ann. Bot. **13**:567–574. *pl. 29.* 1899.

a spiral like those produced by similar treatment in the hypocotyls of grass seedlings.—B. E. LIVINGSTON.

THE ALMOST HOPELESSLY complex chemical changes which are constantly taking place during the life of the organism are gradually beginning to yield to modern methods of experimentation. Recently two papers have appeared on the transformations occurring in phosphorus compounds during germination, one by Iwanow[11], the other by Zaleski[12].

The former used seedlings of *Vicia sativa* grown in phosphorus-free Knop's solution, and determined the amounts of the various phosphorus compounds at the beginning of the cultures and after 5, 10, 15, 20, and 29 days. Determination was made (1) of total phosphorus content, (2) of inorganic phosphorus, (3) of the phosphorus or lecethin, (4) of the phosphorus of proteid compounds, and (5) of that of soluble organic compounds. Zaleski used seedlings of *Lupinus angustifolius*, grown in phosphorus-free sand, and determined the phosphorus (in the same categories of compounds as those determined by Iwanow) at the beginning of the cultures and after 10, 15, and 25 days. Both authors find that during germination inorganic phosphates increase at the expense of organic phosphorus compounds. Iwanow presents evidence that most of this phosphorus comes from the breaking down of phosphorus-containing proteids; some is from the soluble organic bodies bearing phosphorus, and a very little arises from the decomposition of lecethin. Zaleski determined that the decrease in organic phosphorus is mainly in the cotyledons, while the most marked increase in inorganic phosphorus is in the axial organs. He shows also that young and vigorous tips of seedlings of *Vicia faba*, placed in glucose solution, exhibit a less marked decrease in organic phosphorus compounds, as well as less rapid growth, than when these are placed in water. He concludes that the sugar retards both growth and the process of phosphorus-transformation, and that therefore it is possible to suppose a direct relation to exist between the breaking down of organic phosphorus-containing bodies and growth itself.—B. E. LIVINGSTON.

BURKILL[13] has investigated the variation in the floral organs of *Ranunculus arvensis*. From a study of about 7,000 flowers, from seed obtained at Kew, England, and at Bonn and Heidelberg, Germany, he reaches essentially the following conclusions: Each set of floral organs varies according to a law of its own, and none of the curves agrees perfectly with any theoretical probability curve Although the different whorls respond differently to conditions of favorable or unfavorable nutrition, there is always an apportionment

[11] IWANOW, L., Ueber die Umwandlungen des Phosphors beim Keimen der Wicke. Ber. Deutsch. Bot. Gesell. **20**: 366–372. 1902.

[12] ZALESKI, W., Beiträge zur Verwandlung des Eiweiss phosphors in den Pflanzen. Ber Deutsch. Bot. Gesell. **20**: 426–433. 1902.

[13] BURKILL, I. H., On the variation of the flower of *Ranunculus arvensis*. Jour. Asiatic Soc. Bengal **71**:93–120. 1902.

of the available nutrition to the four sets of organs, no set ever being omitted because of the low vitality. If one set of organs is abmodal, all the other sets are likely to be abmodal, but especially the sets which follow. There is a gradual loss of vigor from beginning to end of the flowering period, though a slight recovery just before death was occasionally observed. Of all the floral organs the stamens are most influenced numerically by the relative vigor of the branch, the number being proportionately greater or less according as the whole number of floral parts is above or below the mode. As a result of this greater sensitiveness of the androecium, the flowers are relatively more staminate at the beginning of the flowering season than at any time thereafter. The degrees of constancy in the several sets of organs, beginning with the highest, are in the order: sepals, petals, carpels, stamens. A parallel is drawn between this condition and the relation of these parts to the natural classification, in which it is pointed out that sepals tend to be constant in number through the larger subdivisions of the Spermatophytes, petals in lesser divisions, carpels in the families, and that stamens are so inconstant as to be of little use numerically in a natural classification. The paper is a valuable contribution to our knowledge of floral variation, but the discussions of the problem and the interpretation of the results are rendered vague, and at times incomprehensible, by a diction which constantly suggests the possession of psychic attributes by the various organs or sets of organs.—G. H. SHULL.

ITEMS OF TAXONOMIC INTEREST are as follows: ARTHUR HOLLICK (Torreya **2**: 145–148. *pls. 3–4*. 1902) has described a new species of fossil ferns from the Laramie group of Colorado in Anemia (2), Acrostichum, Polystichum, Gleichenia, and Stenopteris.—T. D. A. COCKERELL (*idem* 154) has described a new Astragalus from New Mexico.—C. V. PIPER (Bull. Torr. Bot. Club **29**: 535–549. 1902), in discussing the biennial and perennial west American species of Lappula, has described 9 new species.—V. S. WHITE (*idem* 550–563), in giving a preliminary list of fungi from Bar Harbor, Mount Desert, Maine, has published new species of Hydnum (2) by H. J. BANKER, and of Boletus, Clitocybe, Cortinarius, and Flammula by C. H. PECK.—J. S. COTTON (*idem* 573–574) has described new species of Glyceria, Astragalus, and Orthocarpus from Washington.—G. F. ATKINSON (Jour. Mycol. **8**: 106–107. 1902) has described two new genera of Basidiomycetes under the names *Tremellodendron* (Tremellineae) and *Eocronartium* (Auriculariaceae), and also (*idem* 110–119) 23 new species distributed among 16 genera.—G. P. CLINTON (*idem* 128–156) has published in preliminary form the results of his studies of North American Ustilagineae, presenting a list of the species with their hosts and distribution, and including descriptions of new species.—H. CHRIST (Bull. Acad. Internat. Geog. Bot. **11**: 189–274. 1902), in giving an account of the Chinese ferns collected by Père Bodinier, under the title *Filices Bodinierianae*, has described new species of Antrophytum, Polypo-

dium (4), Niphobolus, Adiantum, Doryopteris, Blechnum, Asplenium (3), Aspidium (4), Polystichum (5), and Gleichenia; the same author (Bull. Herb. Boiss. II. **2**: 825–832. 1902), in reporting concerning the collection of Père Faurie (*Filices Faurieanae*) from Korea, has described new species of Athyrium (2) and Aspidium.—C. L. POLLARD (Proc. Biol. Soc. Washington **15**: 201–203. 1902) has described two new violets from the eastern United States.—MARCUS E. JONES (Contr. to Western Bot. no. 10) has published a revision of Allium as represented in the Great Basin and adjoining regions, including 3 new species; has presented the Nyctaginaceae of the Great Plateau, including new species of Boerhaavia (2) and Acleisanthes; has described new species of Leptotaenia and Gilia; and has revised the nomenclature of a number of species of Astragalus, including descriptions of 4 new species.—B. FEDTSCHENKO (Acta Hort. Petrop. **19**: 183–349. 1902) has published a detailed revision of Hedysarum, recognizing 78 species, of which 3 are new.—J. M. C.

IN THE PRESENT PAPER Neger[14] has extended the ecological studies begun on Phyllactinia to the whole family of the Erysipheae. Very interesting data are given as to the methods of attachment, as also the setting free and distribution of the perithecia, and the scattered observations of a number of authors are brought together and summarized. The perithecia of Sphaerotheca and Erysiphe are not spontaneously set free from the substratum, and the appendages here serve for attachment. On the other hand, the perithecia of Podosphaera, Trichocladia, Microsphaera, and some Uncinulas are broken loose as a result of unequal shrinkage of the upper and under walls of the perithecia in drying. This makes the ripe and dry perithecium either flat or concave on its under side, as has also been observed by Galloway. Just how this deformation leads to the setting free of the perithecia is perhaps still not clear. The interlacing of the appendages serves to hold adjacent perithecia together so that they fall from the host leaf in masses rather than singly. In Phyllactinia the perithecia are set free by the bending downwards of the spine-like appendages which thus lift up the perithecium from the surface of the leaf. The author also discusses the question as to the causes which lead to the formation of the sexual and asexual fruit organs, and concludes that the conidia are favored by a fresh vigorous condition of the host plant, while the perithecia are more likely to be formed in well developed mycelia on mature parts of the host, which, however, must not have been already exhausted by a too abundant crop of conidia.

The earlier paper[15] describes very extensive germination experiments and studies on the form, length, irritability, etc., of the germ tubes of the

[14] NEGER, F. W., Beiträge zur Biologie der Erysipheen. Flora **88**: 333–370. *pls. 16–17.* 1901.

[15] NEGER, F. W., Zur Kenntniss der Gattung Phyllactinia. Ber. Deutsch. Bot. Gesell. **17**: 235. 1899.

conidia. The author believes that in such genera as Erysiphe the characters of the germ tubes may be advantageously used in defining the limits of difficult species. In every case the germ tubes showed themselves incapable of nourishing themselves from any nutrient media offered. Their size was limited strictly by the amount of reserve material present in the spore. Different lots of conidia also varied widely in the percentage of germination. Light favors germination and the germ tubes are in many cases positively heliotropic. In many cases also the germ tubes show themselves sensitive to contact stimuli. A considerable series of infection experiments were made, and although the evidence was by no means conclusive many results indicated that in the mildews, as in the rusts, we have numerous cases of physiological species, inhabiting only one host plant, within the limits of the species as at present commonly accepted. Cases are also pointed out in which it seems likely that the ascospores may be capable of infecting a wider series of hosts than can the conidia. The theoretical aspects of the data so obtained are discussed at some length. A further interesting observation of the author is that the little known conidia of Phyllactinia are borne in the ordinary basipetal series and not singly as described by Tulasne. Of theoretical interest further is the suggestion that the development of hyphae and haustoria, which penetrate to the interior of the host leaf, as described by Palla and Smith, is correlated with the degree of hypertrophy produced by haustoria in the epidermal cells of the host. The haustoria restrict themselves to the epidermis in cases like Sphaerotheca, in which the cells of the latter are hypertrophied, and thus (?) produce an abundant food supply for the parasite.—R. A. HARPER.

RECENT CONTRIBUTIONS TO AMERICAN PHYTOGEOGRAPHY: the Eastern United States.—E. F. WILLIAMS (Rhodora 3: 160–165. 1901) makes a comparison of Mounts Washington and Ktaadn, finding general similarity. Mount Ktaadn, however, has a more rugged and arctic aspect, the timber line being exceedingly low; an interesting colony of lowland plants was found well up toward the summit.—J. W. HARSHBERGER (Plant World 5: 21–28. 1902) gives a brief ecological account of Mount Ktaadn, in which the lowland timber areas are also described.—C. D. HOWE (Science 15: 462. 1902) gives a preliminary account of his studies on a delta plain in Vermont; the development of the vegetation is traced from the beach, through the *Pinus rigida* stage, to the culminating forest of beech and maple. The life history in Vermont is found to be essentially like that in Michigan, as worked out by Cowles and Whitford.—C. H. SHAW (BOT. GAZ. 33: 437–450. 1902) discusses very suggestively the development of vegetation in morainal depressions near Woods Hole. Physical agents are found to control the filling of ponds in some cases, as evidenced by open marginal belts of water. *Euthamia graminifolia* flourishes on sandy shores by reason of its running stems; beyond this there are no plants until the depositing zone is passed, where Limnanthemum and other runnerless plants occur. Marginal ditches

about floating mats are explained by the great abundance of falling leaves, which smothers out the vegetation. The vegetation is not xerophytic in structure in the earlier stages.—A. HOLLICK (Bull. N. Y. Bot. Gard. **2**: 381–407. 1902; see also Torreya **2**: 58–59. 1902), in a paper dealing chiefly with geological phenomena, gives a short account of the vegetation of Cape Cod. Apparently the dunes of Provincetown were once well forested, while it is now difficult to secure artificial reforestration. To account for this Hollick advances the view that a forest can develop *pari passu* with the increasing piles of sand; if, however, the trees are cut off, the drifting sand makes reforestration difficult or impossible. The vegetation is treated in two groups, that of the forest (dominated by *Pinus rigida*, *Quercus rubra*, and *Q. velutina*), and that of the bare sands, subdivided into beach and dunes. Reference has previously been made (BOT. GAZ. **31**: 134. 1901) to the excellent work of HOLLICK on the forests of New Jersey.—J. W. HARSHBERGER (Proc. Acad. Nat. Sci. Philadelphia 1900: 623–671) has made an ecological study of the New Jersey strand flora. He finds a plantless lower beach, a middle beach with Cakile and other succulents, and an upper beach with much *Oenothera humifusa*, a plant of southern range. The seaward dunes are dominated by Ammophila, while farther inland *Myrica cerifera* and Hudsonia assume the leading place. The tree-clad strand is dominated by weather-beaten junipers, and there is also a jungle zone of trees, shrubs, and lianas. The salt marshes are also considered.—C. F. SAUNDERS (*idem* 544–549) describes the pine barrens and sphagnous bogs of New Jersey.—A. MACELWEE (*idem* 482–490) considers the flora of Edgehill ridge, Montgomery county, Pa., three societies being discussed, namely, sunshine, shade, and sphagnous bog.

T. H. KEARNEY (Contrib. U. S. Nat. Herb. **5**: 261–319. 1900) has published a short but interesting account of the vegetation of Ocracoke island, North Carolina. While many forms are common to northern beaches and dunes, such plants as *Croton maritimus* dominate on the beach, and *Uniola paniculata* on the outer dunes. Live oaks rule in the groves, and *Ilex vomitoria* in the thickets. The salt marshes have many familiar northern types. The mingling of salt and fresh water forms is explained by alternations of salty spray and rainfall; perhaps, however, fresh conditions are encroaching upon the salt, leaving the salt marsh forms as relicts. Interesting anatomical studies upon salt marsh plants confirm the prevalent notion of their xerophytic structure. The island is placed in Merriam's Austroriparian, though many typical plants are absent and others present.—D. S. JOHNSON (BOT. GAZ. **30**: 405–410. 1900) gives some ecological notes on the seed plants and algae at Beaufort, N. C.

T. H. KEARNEY (Contrib. U. S. Nat. Herb. **5**: 321–585. 1901) gives a most excellent account of the vegetation of the Dismal Swamp region. The paper is splendidly illustrated with plates and numerous figures, and is one of the most valuable of recent contributions to plant geography. He regards the region as belonging to Schimper's ever-moist warm temperate zone, though differing

from most similar regions in that deciduous trees dominate instead of evergreens. The salt marshes with Spartina, Salicornia, and other characteristic plants pass gradually into Typha swamps. Among the noteworthy "adaptations" are sheaths which prevent the access of salt water, anchoring rhizomes, and a number of well-known xerophytic structures. The beach flora is sparse, and resembles the more northern beaches. Dunes are well developed and are in some cases eighty feet high; Ammophila is the character plant of the outer dunes, but the more southern *Uniola* also has a place. The occurrence of *Salix longifolia*, Cephalanthus, and Baccharis on the dunes is cited as an evidence of the sand moisture; perhaps they also indicate the advance of a dune over a swamp. The occurrence of *Acer rubrum* and *Nyssa sylvatica* on the lee dune slopes may have a similar explanation, as is the case on Cape Cod. The abundance of *Pinus Taeda* with live oaks on the forested dunes gives a southern aspect, though many of the character plants remain such far to the northward; lianas are highly developed. The usual xerophytic "adaptations" are noted, though neither the soil nor air is dry. The character of the drainage is the chief factor which determines the nature of the inland vegetation. *Pinus Taeda* is the leading forest tree, though it is readily followed by hardwoods in most places if removed. Abandoned fields are first colonized by *Andropogon virginicus*, and later by pines. The leading deciduous tree is Liquidambar, although oaks are abundant; Fagus occurs in rich soil. The swamps are of two types: (1) the dark or black gum swamp, which contains *Acer rubrum* and Taxodium as well; (2) the light or "Juniper" swamp, in which Chamaecyparis rules, and in which there is less water, though what occurs is more acid. This region is the northeastern terminus of Merriam's Austroriparian; many southern and a few northern plants reach here their limits. The analysis of many important topics is keen, and the paper is a highly welcome addition to ecological literature.

C. C. ADAMS (Biol. Bull. 3: 115–131. 1902) in a most valuable paper discusses the southeastern United States as a center of distribution. His data are derived in the main from zoological material, but his conclusions are of general interest. Among the criteria for determining a distribution center, aside from fossil evidence, he gives the location of greatest differentiation, of dominance or abundance, of maximum size, of productiveness, of continuity and convergence of lines of dispersal, of least dependence upon a restricted habitat, of continuity and directness of variation along radiating lines of dispersal. Using these and other criteria Adams shows the southeastern United States to be a great center of dispersal, at least for animals. The chief highways have been the Atlantic coast, the Mississippi valley, the Appalachian mountains. He makes a just plea for the dendritic as against the zonal study of life; lines of dispersal and divergence give a clue to many of the great biological problems. This type of study is dynamic and genetic, and thus has a great advantage over the more common methods.— Reference has been previously made to the work of KEARNEY in the Appalachian

region (BOT. GAZ. 31:208. 1901), also to GATTINGER'S Tennessee flora (BOT. GAZ. 32:428. 1901), in which the various regions of the state are described as to their vegetation.

R. M. HARPER (Bull. Torr. Bot. Club 27:320–341; 413–436. 1900) has given some interesting data concerning the flora of Georgia. Northern and southern Georgia are quite different, the former having a flora like that farther north, while southern Georgia has true southern types. Lists are given of many plant communities. More recently (Science 16:68–70. 1902) the same author has written a brief account of the botanical features of the Lafayette and Columbia formations. He finds that it is possible to distinguish these formations by the plants which grow upon them. *Eriogonum tomentosum* and *Froelichia Floridana* especially characterize the Columbia sands. Harper (Bull. Torr. Bot. Club 29: 383–399. 1902) has also published a paper which deals with the distribution of Taxodium. He thinks that there are two species, *T. distichum* and *T. imbricarium*, and that the latter always occur on Lafayette soil, the former never. It seems to the reviewer that *T. imbricarium* will prove to be merely an ecological variety, similar to varieties of ferns and violets which Sadebeck years ago experimentally transformed to the parent species.

C. L. POLLARD (*Plant World* 5:8–10. 1902) notes how the mangroves and other species assist in the formation of the Florida keys, commencing where the corals leave off. Rhizophora is the pioneer, but is soon followed by Laguncularia and Conocarpus. When the mangroves die out, we have the "hammock" land.—CHAS. MOHR'S flora of Alabama has been reviewed in these pages (BOT. GAZ. 32:371. 1901). This work is one of the most complete and satisfactory that has yet appeared in this country, being nothing less than a mine of floristic and ecological information. He notes that in Alabama Merriam's life zones correspond with the geological formations rather than with the climate. The hemlock and sweet birch occur far from their main range, and are relicts of the glacial invasion. A number of interesting endemic and local forms are noted.—LLOYD and TRACY (Bull. Torr. Bot. Club 28:61–101. 1901) have made an ecological study of the insular flora of Mississippi and Louisiana. This paper is a noteworthy addition, especially as it gives us a means of comparing our northern and southern coasts. The islands are deposits of Mississippi river detritus; in some cases the mud is still the surface material, in other cases it is covered by sand. On the beach northern forms like Salsola and Strophostyles are mingled with the more tropical Ipomoea. Dunes are formed by *Panicum amarum* and Uniola. The palm Serenoa, and other plants form "pedestal" dunes. Sand plains are described of various types, culminating in a forest of pines and live oaks with an undergrowth of palms. A unique set of vegetation conditions is found on the shell strand. Among the leading salt marsh plants are Batis, Avicennia, and Salicornia.

A. J. PIETERS (U. S. Fish Commission Bull. 1901: 57–79) contributes an

important paper on the plants of western Lake Erie. The groups of water and swamp plants are presented. The usual hydrophytic "adaptations" are found, and a number of anatomical figures are given. Some excellent plates, showing the life forms of character species, especially Chara, accompany the article.— H. W. CLARK (Proc. Ind. Acad. Sci. 1901 : 128–192. 1902) gives a list of plants with ecological notes from Eagle (or Winona) lake, Indiana, and vicinity.— MISS LUCY YOUSE (*idem* 192–204) discusses the plant ecology of Winona lake. She treats the dynamics of the vegetation, sketching the changes from the lake and swamp stages to the forest or prairie, and from the bare morainic hills to the forest of beech and maple.—W. M. MILLS (Chicago: The Quadrangle Press. 1902) has also studied the above lake, mainly from the standpoint of physiography, but adds some ecological notes. —M. T. COOK (Proc. Ind. Acad. Sci. 1901 : 266–272. 1902) sketches the development of vegetation in abandoned rock quarries at Greencastle, Indiana.—E. J. HILL (Bull. Torr. Bot. Club **29** : 564–570. 1902) gives some notes on recent adventives in the Chicago flora.—F. E. MCDONALD (Plant World **3** : 101–103. 1900) describes a sand dune flora in central Illinois, along the Illinois river. Dunes of pure sand, some a hundred feet high, are formed. *Quercus Marylandica* is the leading tree. As might be expected, many species are common to the Lake Michigan dunes.— H. C. COWLES' paper on the physiographic ecology of Chicago and vicinity appeared in this journal (BOT. GAZ. **31** : 73–108, 145–182. 1901), as well as H. N. WHITFORD'S paper (*idem* 289–325) on the genetic development of the forests of northern Michigan, and E. J. HILL'S paper (*idem* **29** : 419–436. 1900) on the flora of the White Lake region, Michigan.— C. A. DAVIS (Jour. Geol. **9** : 491–506. 1901) has confirmed his previous view on the origin of Michigan marl (see BOT. GAZ. **31** : 361. 1901), and adds some new results.— EMMA J. COLE'S catalogue of the Grand Rapids (Michigan) flora has been noticed (BOT. GAZ. **31** : 437. 1901); a number of southern trees, such as Asimina, Cercis, Carya, Morus, Nyssa, Gymnocladus, Liriodendron, *Cornus florida*, probably find here their northern limit.— V. M. SPALDING (Science **15** : 402. 1902) has projected a survey of the Huron valley, Michigan. The influence of artificial changes on certain plastic forms has been very great.— H. S. REED (BOT. GAZ. **34** : 125–139. 1902) has contributed the first paper to the above survey. His topic is the ecology of a glacial lake, and the paper is particularly valuable because of its dynamic treatment and careful quantitative work.— H. C. COWLES' paper dealing with the influence of underlying rock upon the vegetation has been reviewed previously (BOT. GAZ. **33** : 316. 1902)— B. E. LIVINGSTON (Report Mich. Geol. Surv. 1901 : 79–103. 1902) has published on the distribution of the plant societies in Kent co., Michigan. His results will soon be published in this journal, and it may be merely noted here that his physiographic results agree with those of the reviewer. He strongly urges the moisture-retaining power of the soil as the decisive factor in plant distribution.— E. BRUNCKEN'S valuable studies in Wisconsin have been noted (BOT. GAZ. **34** : 149. 1902). —H. C. COWLES.

NEWS.

DR. THEODOR VON HELDREICH, director of the Botanical Gardens at Athens, died recently at the age of eighty years.

PROFESSOR A. ENGLER, of the University of Berlin, has been for some time engaged in a botanical expedition to Africa.

PROFESSOR F. E. WEISS, of Owens College, Manchester, England, has been visiting some of the prominent botanical laboratories of the United States.

IN THE NEW EDITION of his *Plant Breeding*, which will probably be in the market next month, Professor Bailey will include a full presentation of the recent theories of De Vries and Mendel.

DR. E. PERCEVAL WRIGHT, Professor of Botany at Dublin University, calls attention to the fact that the Herbarium of Trinity College contains such collections as Harvey's extensive series of Algae, Thomas Coulter's collection of Californian plants, etc., and has kindly offered to give any information in his power concerning them.

ERRATUM.—In Mr. Chandler's paper on Nemophila (BOT. GAZ. 34 : 194–215. *pls. 2–5*. 1902), the legends of *Plates IV* and *V* should be interchanged, *Plate IV* being *N. exilis* Eastwood, and *Plate V* being *N. parviflora* Dougl. As a consequence, the two plate numbers should be interchanged in the "Explanation of plates," p. 215.

ACCORDING to a recent estimate made by the Bureau of Forestry into the losses from forest fires, the conclusion is reached that in an average year 60 human lives are lost, $25,000,000 worth of real property is destroyed, 10,274,089 acres of timber land are burned over, and young forest growth worth at the lowest estimate $75,000,000 is killed.

SARGENT'S SILVA OF NORTH AMERICA is complete with the publication of volumes XIII and XIV this autumn. This great work has been twelve years in preparation, contains 750 plates from drawings by C. E. Faxon, and describes and illustrates 567 species of American trees north of Mexico. A new work only less extensive, by the same author and artist, and entitled *Trees and Shrubs*, will begin to appear this autumn. It will be published in several large quarto volumes, with four parts to a volume, and will illustrate new or little known woody plants, especially those of the northern hemisphere which may be expected to flourish in the gardens of the United States and Europe.